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EXPERIENCES IN SPINAL SURGERY[1]

OBSERVATIONS UPON 60 LAMINECTOMIES FOR SPINAL DISEASE

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THE following observations were made upon 70 consecutive operations for spinal disease. There were 60 primary laminectomies and 10 secondary operations. Laminectomy was performed 22 times for tumor, 9 times for section of posterior roots for pain or spasticity, 4 times for inflammatory bone disease, 5 times for old fracture of the spine, twice for syringo- and hydromyelia, once for intramedullary cyst, once for an arteriovenous aneurysm of the posterior spinal vessels, and 3 times for a peculiar disease of the roots of the cauda equina. In 13 patients not enough was found to explain the symptoms.[2]

In the future, when sufficient time has elapsed, I shall report on the final results in the entire series of patients. As the improvement in most of the patients is of necessity slow and gradual, years must pass before any definite statements of the end results can be made. In this place I desire to lay emphasis on the fact that the mortality of the operation of laminectomy should be a small one. I have recently operated upon the fortieth successive laminectomy for spinal disease without fatality from the operation. In experienced hands, a laminectomy is neither a particularly hazardous nor a trying operation, and at the Neurological Institute we have come to look upon a laminectomy in a patient in good general condition as a fairly safe operation.

THE SPECIAL FIELD OF SPINAL SURGERY

Although there are many gaps in our knowledge of the anatomy and physiology of the spinal cord, and of the exact course and relations of the conducting tracts, the recent advances in this field have been many and important. We may confidently expect that much will be added to our knowledge in the near future as a result of clinical and experimental research. In not a few instances, we are already able to diagnosticate the exact level of a spinal lesion and the tracts most affected, and not so rarely we can recognize in what direction the disease process is advancing and therefore say beforehand in what succession other fibres will have their functions compromised.

The surgeon who desires to have the best results in his spinal operations must have a good working knowledge of spinal physiology and pathology, he must be able to determine for himself the level and relations of a spinal lesion, and should be able to recognize, as

[2] The greater number of these operations were performed by the writer at the New York Neurological Institute; some were done at the Mt. Sinai Hospital, the Montefiore Home for Chronic Invalids, and at the patients' homes. Seven patients were operated upon by Dr. E. Beer (section of posterior roots, 4 cases; intramedullary tumor, 1 case; removal of cauda tumor, 1 case; exploratory, 1 case). I desire to thank the gentlemen who referred the patients to me for operation: Drs. Collins, Bailey, Peterson, Fränkel, Kennedy of the Neurological Institute, and Drs. Dana, Starr, Sachs, Abrahamson, Strauss and Lesynsky.

[1] Read at the meeting of the Mississippi Valley Medical Association, Chicago, October 23, 1912.

far as our present knowledge will permit, its nature. Then he will be able to construct in his own mind a picture of the condition of affairs in the spinal canal and thoroughly to understand the manner in which the disease is interfering with the cord's functions. The spinal surgeon will surely be required, more and more often, to invade the tissues of the spinal cord itself, and to attack the cord on its anterior as well as on its posterior aspect. The operative procedures must be planned to meet the indications in each individual case.

SOME FEATURES OF THE TECHNIQUE OF LAMINECTOMY

After some experience, the technique of the operation of laminectomy is seldom difficult. The incision of the skin, the separation of the fascia and muscles from the bones, and the removal of the spinous processes and laminæ so as to lay the spinal canal wide open, is a purely mechanical part of the operation and should be accomplished with very little expenditure of time so that the strength of the patient is little taxed before the actual manipulations around the spinal cord are begun. Osteoplastic flap operations are inadvisable and unnecessary, because they are more time consuming and more bloody and do not give as free access to all sides of the cord. The operation of hemilaminectomy is appropriate, I think, for only very few cases, for the same reasons that I have just given. A wide exposure of the spinal canal is usually necessary, both for the purpose of exploration and in order that there shall be as little handling of the cord as possible. The operator should consider that every time that he touches the cord he is doing harm; only then will he have the proper respect for the delicate spinal tissues.

In its technical aspects, spinal surgery has a great advantage over cranial surgery. No matter how skillful and expeditious the operator, the exposure of a part of the brain is of necessity a time-consuming procedure, and the patient's resisting powers are often sorely taxed by the time the dura is exposed. For this reason operations upon the brain are often done in two stages. In spinal surgery, on the other hand, the mechanical part of the operation can be accomplished very rapidly if the surgeon has some experience and has provided himself with the proper instrumentarium. Two-stage operations are sometimes necessary when the laminectomy is done high up in the cervical region, and when a tumor is to be removed from the interior of the cord by the method of extrusion.

For ordinary purposes, at least two or three spines and laminæ have to be removed, but I have often had to remove as many as five to seven before the entire lesion was exposed. The support of the spinal column depends mainly upon the bodies of the vertebræ, and the functions of the spine are well preserved even after seven spinous processes and laminæ have been removed.

The dura mater should always be tightly closed after the completion of a spinal operation (excepting in the cases to which reference will be made later), and the muscles, fascia, and skin very carefully closed by interrupted sutures. The careful layer suture of the paravertebral muscles will contribute much to the perfect recovery of the mobility of the spinal column after a laminectomy.

Oozing from the muscles should always be carefully controlled before the dura is incised. The pia-arachnoid can usually be opened separately, so that even if there is a little blood within the dural sac it will not come into direct contact with the cord; and hence those paræsthesias and root pains can be prevented which sometimes follow spinal operations and are due to bleeding into the subarachnoid space.

A laminectomy wound should never be drained; the careful closure of the dura, muscles, fascia, and skin will be the surest preventative of cerebrospinal fluid leakage and the greatest safeguard against meningeal infection. Even when the dura is left open, leakage of cerebrospinal fluid should practically never occur if muscles, fascia, and skin have been well sutured.

When the laminectomy has been done in the cervical region, it is advisable to immobilize the cervical and upper dorsal spine by means of a large posterior splint, but in the dorsal and lumbar regions, no immobiliza-

tion of the spine is necessary. The patients should be kept flat on the back for the first few days, and they usually prefer that position as the most comfortable. When the laminectomy has been done in the lowermost dorsal or lumbar and sacral regions, great care should be taken that the dressings are applied so as to guard against soiling of the wound with urine or fæces. This is, of course, very important, for so many of the patients who require a spinal operation in one of these regions are, from the nature of their disease, more or less incontinent of urine and fæces.

THE SIGNIFICANCE OF A POSITIVE WASSERMANN REACTION IN PATIENTS WITH SYMPTOMS OF SPINAL TUMOR

The great value and importance of the Wassermann reaction is universally recognized, but I am not at all certain that its importance in patients who have a surgical spinal lesion has not been somewhat overestimated. In times gone by, a previous syphilitic infection was excluded by means of a thorough course of mercury and iodides, even if no history of a specific infection could be obtained. By means of the serum reaction, many patients are saved from an unnecessary and useless course of treatment. But what position shall we take in the case of a patient with the symptoms of a spinal tumor, who gives no history of a syphilitic infection, and in whom the Wassermann reaction in the blood or cerebrospinal fluid, or in both, is positive? How long is it fair to delay surgical interference? If the symptoms do not recede or continue to progress after an intravenous injection of salvarsan, is further delay justified? I believe that it is almost as great an error to allow a patient with a suspected spinal tumor — even if it be a gumma — to become totally paraplegic while antisyphilitic remedies are being given, as to allow a patient with a possibly syphilitic brain tumor to become blind while internal measures are being tried. There is no reason why a patient with a positive Wassermann reaction in the blood and cerebrospinal fluid may not also have a spinal tumor. I have twice removed an extramedullary glioma from the cord of patients whose Wassermann reaction was positive. Horsley states that it is his belief that a gumma that is of sufficient size to give marked symptoms of brain or spinal tumor should be operated upon. As far as gumma of the spinal cord is concerned, I agree with Horsley's radical view, with the one proviso that an intravenous injection of salvarsan has not caused a marked and rapid improvement. Irreparable injury to the cord may be done by a gummatous growth before it has yielded to antisyphilitic remedies.

ERRORS THAT MAY OCCUR IN THE DIAGNOSIS OF THE LEVEL OF THE LESION — LATE VERSUS EARLY SYMPTOMS

The correct diagnosis of the level of the lesion can be made in most instances if careful and repeated examinations have been made, and the disease will be exposed by the operator if he has removed the correct spinous processes and laminæ.

I desire to call special attention, however, to what may be called the late symptoms of spinal disease which may be likened to the late symptoms of intracranial disease. As in the case of brain disease, these late symptoms may overshadow the true localizing symptoms. Therefore, it is important to obtain a careful history of the early symptoms and the order of their appearance.

If there has been, for a long period of time, a stasis of cerebrospinal fluid above the level of a spinal tumor, motor and sensory symptoms may occur which are due entirely to the pressure of the fluid. In the beginning, these symptoms are irritative; later they are true pressure symptoms. They may give level symptoms far above the real level. The following patient had an extramedullary glioma at the level of the eighth dorsal segment, which was successfully removed, but for many months she had motor and sensory symptoms which pointed to a lesion at the level of the third dorsal segment.

EXTRAMEDULLARY GLIOMA OF THE EIGHTH DORSAL SEGMENT; LAMINECTOMY; REMOVAL; RECOVERY

Mrs. H. S., 57 years of age, admitted to the Montefiore Home on the service of Dr. I. Strauss, on November 17, 1911. Patient is married and has nine healthy living children; never had any

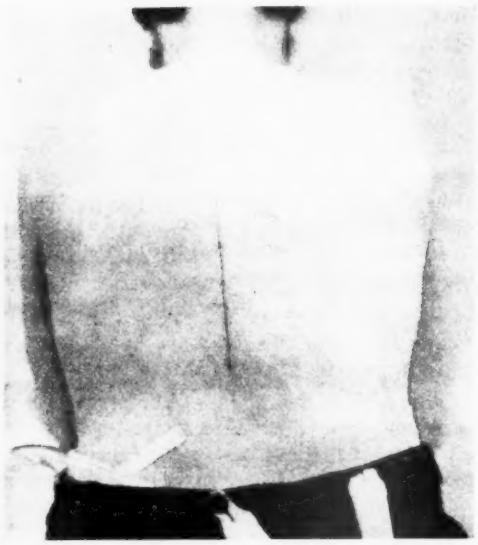

Fig. 1. Appearance of back four weeks after laminectomy.

Fig. 2. Patient M. G. Appearance of back four weeks after laminectomy with removal of six spines and laminæ.

miscarriage. Ill since sixteen months, beginning with numbness and tingling sensations in the soles of the feet, extending up to hips; painful cramps in legs; increasing loss of sensation, first in left then in right lower extremity. Increasing stiffness and loss of power in the lower limbs. After one year, girdle sensation, inability to walk, loss of control of bladder and rectum. For several months before admission, tingling in right arm and hand and increasing weakness.

Examination showed complete spastic paraplegia in the lower extremities, with exaggerated reflexes, clonus and Babinski. Complete loss of all sensations up to the level of the eighth dorsal area. Wassermann positive, salvarsan and mercury; slight improvement in the lower limbs, but gradually developing weakness of right and then of left upper extremity; marked loss of all three sensations up to level of D_3.

February, 1912: Level of sensory disturbances at third dorsal. Diagnosis at this time, intradural obstruction at level of third dorsal segment. Operation advised at this level, but delayed because of positive Wassermann.

May: Spasticity of the lower limbs much worse; very marked disturbances of sensation in ulnar distribution in both upper extremities.

June 14: Laminectomy at level of the eighth dorsal segment, on account of most marked symptoms at this level (Dr. Elsberg). Spines and laminæ of seventh, eighth and ninth dorsal vertebræ removed in the usual manner; incision of dura at level of eighth dorsal; to the right and behind cord, a small tumor, 2 x 1 cm. in size, easily removed. Suture of dura, muscles, fascia, skin, in the usual manner. Duration of the operation, 35 minutes; uncomplicated recovery.

REMARKS

This case is of very great interest. For a number of months there was a well marked sensory and motor level at the third dorsal segment. If an operation had been performed during this period (about four months) there would have been every justification for a diagnosis of a lesion at that level and for an opening in the same place — five segments above the true seat of the tumor. The operation was done so low down because it was thought that the high signs were probably due to fluid above the site of the tumor. It is of interest also that the patient had a positive Wassermann reaction, and that the tumor that was removed was a typical glioma.

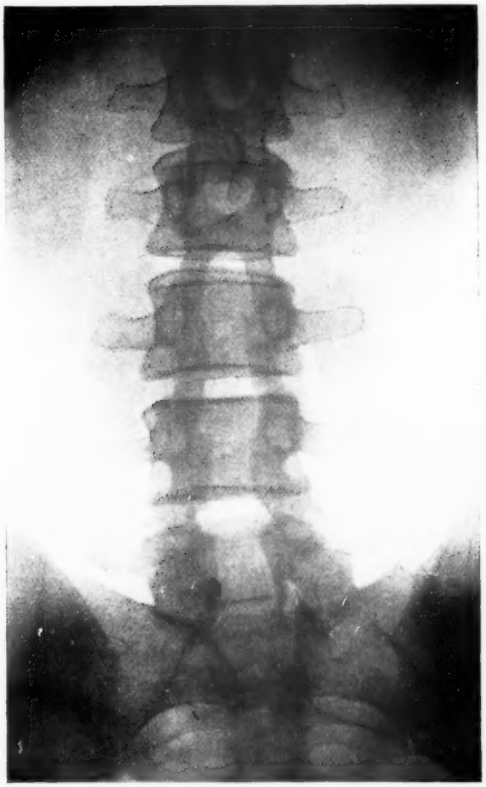

Fig. 3. Helen H. X-ray six months after laminectomy for tumor of conus and cauda equina.

Fig. 4. X-ray six months after laminectomy for intradural tumor of spinal cord.

Secondary degenerations in the cord may, in rare instances, cause a shifting upwards of the level of the sensory and motor symptoms. I have operated upon one patient in whom this error had been made, and the tumor was at first sought too high up.

ON THE SUPPOSED DANGER FROM THE SUDDEN ESCAPE OF CEREBROSPINAL FLUID WHEN THE DURA IS OPENED

It is well known that the sudden removal of a large quantity of cerebrospinal fluid by lumbar puncture is often followed by severe general symptoms, such as headache, vomiting, syncope, and sometimes collapse. Most writers speak of the danger of sudden collapse of the patient during an operation, when there is a sudden escape of a large amount of cerebrospinal fluid. Our experience is entirely against the view that dangerous symptoms result from this escape of fluid. In over 70 spinal operations, I have never seen symptoms which could fairly be ascribed to the escape of the cerebrospinal fluid when the dura was incised. On theoretical grounds, such an occurrence would be surprising. As has been shown by Grashey, Krönig, Propping, and others, the pressure of the spinal fluid in the lumbar region, when the patient is in the horizontal position, is almost zero under normal conditions. When there is pressure on the cord, this pressure may be raised; but it surely can never equal the atmospheric pressure. When the dura is opened, a pres-

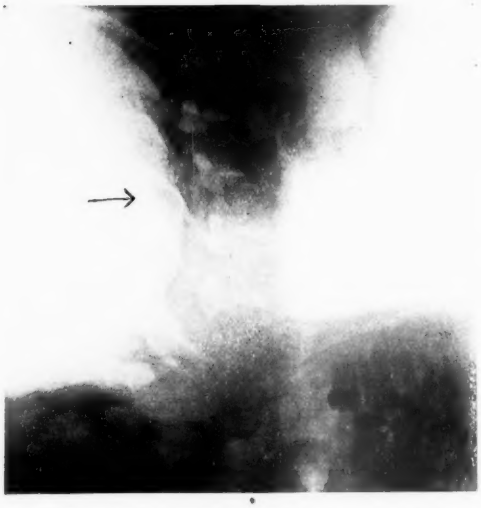

Fig. 5. Pierre H. Compression of cord after old fracture. Dislocation of spine in cervical region. The X-ray plate shows the marked deformation of the spinal cord.

sure of sixteen pounds to the square inch replaces the intradural pressure. It seems to me that it is much more probable that the symptoms which have often been observed were due to prolonged manipulations which had gone before and to the handling of the cord itself. On no other basis can I explain the entire absence in our series. We are accustomed, however, to lower the end of the table as soon as the fluid begins to escape, if it be in large amount.

THE OCCURRENCE OF BLADDER DISTURBANCES AFTER LAMINECTOMY—ABDOMINAL DISTENTION AFTER LAMINECTOMY IN THE DORSAL REGION

Even if no disturbances of the bladder existed before the operation, they are very likely to occur afterwards. Usually, there is retention of urine for a few days; rarely, this persists for several weeks. When the laminectomy has been done in the lumbosacral region, the retention is accompanied by a lack of feeling of bladder distention; after an operation in the dorsal or cervical region, the patient will know when his bladder is distended. When the patient regains the control of his bladder, he is, at first, able to empty the bladder only partly, and it often requires several days before the bladder can be entirely emptied.

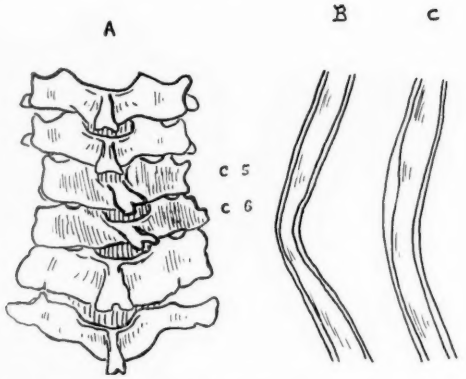

Fig. 6. Pierre H. (*a*) Outline of cervical vertebræ, showing rotation of fifth and sixth cervical vertebræ. (*b*) Angulation of cord found at operation. (*c*) Relief of angulation of cord after removal of spines and laminæ of the fourth, fifth and sixth vertebræ. The laminectomy was followed by marked and steady improvement in the patient's symptoms.

Unless incontinence existed before the laminectomy it should rarely occur afterwards. If such incontinence does occur, it

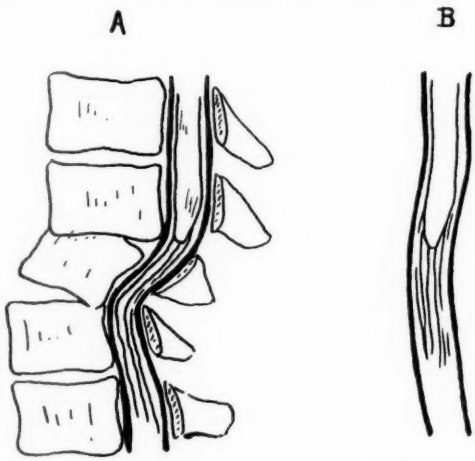

Fig. 7. Laura L. Old fracture of spine; marked improvement after laminectomy. (*a*) shows the appearance of the spine with pressure on the cord and cauda equina; (*b*) shows how the conus and cauda were allowed to straighten out after the free removal of spinous processes and laminæ. (Diagrammatic.)

Fig. 8. Mary G. Old fracture of spine with marked deformation.

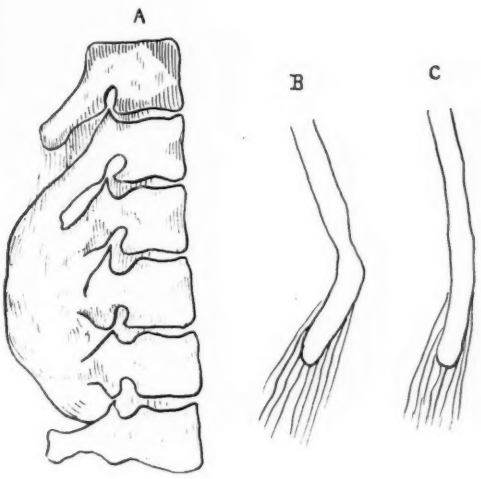

Fig. 9. Mary G. Compression of cord from old fracture of spine; marked improvement after laminectomy. (*a*) shows the marked mass of bone which bound together the spines and caused narrowing of the spinal canal and angulation of the cord. (*b*) shows the angulation of the cord found at operation. (*c*) shows the appearance of the cord after the removal of the bony masses. (Diagrammatic.)

usually means that some injury has been done to the cord or that there has been considerable bleeding within the sac of the pia-arachnoid. If the incontinence is due to the latter cause, it will usually disappear within a few days or weeks; if due to the former, it may persist for months; and if the injury to the cord has caused a more or less complete transverse lesion, it may be permanent.

Retention of urine calls for regular catheterizations three or four times in twenty-four hours, and care should be taken that the bladder never becomes overdistended. Overdistention is very apt to favor cystitis. Urotropin is to be given after every spinal operation for several weeks, and its use must be continued longer if the patient has to be catheterized.

After the removal of a tumor or other disease of the cauda equina which has caused retention of urine as one of the symptoms, the retention of urine may persist for a number of months. In these patients, one can often stimulate the bladder to empty itself by suddenly removing the catheter during catheterization, at the same time that the patient is told to attempt to void his urine with the catheter in place.

Abdominal distention may occur after a laminectomy, as after any other operation. But it occurs very frequently after a laminectomy in the lower dorsal region (D_9 to D_{12}). After a spinal operation at this level, a very marked and, to the patient, very distressing abdominal distention often occurs, which can be only partly relieved by cathartics or enemata, and which usually persists for several days. The patients are unable to pass any gas, the abdomen is enormously distended, and vomiting sometimes occurs, so that to one who has not seen the condition, the patient seems to present the clinical picture of acute intestinal obstruction. I have seen this condition a number of times, and it has regularly subsided in the course of a few days. The best treatment, in addition to enemata, seems to be small repeated doses of morphin and atropin.

Fig. 10. Mrs. J. S. C. Old fracture of lamina of the fourth lumbar vertebra.

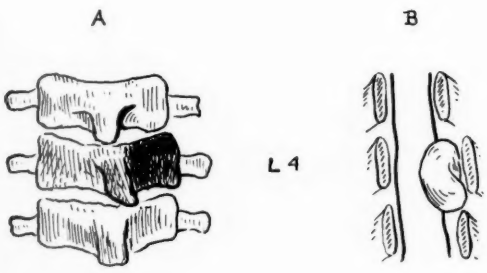

Fig. 11. Mrs. J. S. C. Appearance of fractured lamina at operation; (*b*) shows the torn and coiled up ligamentum flavum which compressed the fourth lumbar root. Laminectomy and removal of the torn ligament was followed by complete relief.

THE APPEARANCE OF THE SPINE AND THE FUNCTIONS OF THE SPINAL COLUMN AFTER COMPLETE LAMINECTOMY

From the æsthetic standpoint, the appearance of the back of a patient upon whom a complete laminectomy has been done leaves nothing to be desired (Figs. 1 and 2). Excepting for the linear cicatrix, the contour of the back appears almost normal. Sometimes the spinous processes above and below the operative area are somewhat prominent; when this is noticed at the time of the operation, one can rongeur away a small piece of the spines, just above and below the region exposed, before the fascia and skin are closed by suture.

The amount of bone that must usually be removed in the operation of laminectomy is shown in the accompanying X-ray pictures (Figs. 3 and 4). The scar tissue that is formed between the divided laminæ and the skin is exceedingly dense and hard and forms an excellent protection for the cord beneath. In this scar tissue there are often areas of bone formation, and occasionally an entirely new vertebral arch is formed.

The free mobility of the spinal column is usually fully recovered. For a number of days after the operation, movement of the head, trunk, or extremities will cause pain in the part of the spine that has been operated upon. As soon as this pain disappears the patients are able to turn freely, and within ten to fourteen days they are able to sit up and begin to walk.

For a few months after the laminectomy there is often considerable local stiffness and rigidity of the spines, especially when the patient attempts to bend forward or backward. Lateral mobility is generally well preserved. In some cases, however, the patient is able to move his spine freely in all directions a few weeks after the laminectomy.

Rigidity of the spine is much more apt to be prolonged after laminectomy in the lower dorsal and lumbar regions, and considerable massage and exercises are sometimes necessary before the entire vertebral column regains its normal mobility. In the cervical and upper dorsal regions, the patients very quickly regain the power of free movement of the head in all directions. Some of these patients have a tendency to carry the head somewhat forward, as if there had remained some weakness of the spinal muscles in the cervical region. This muscular weakness soon disappears. Six months or a year after a laminectomy has been done, the vertebral column will be found to be as freely movable as the normal, or as it would have been in the individual case if no operation had been performed.

THE SURGICAL FEATURES OF OLD FRACTURE OF THE SPINE

The results that have followed operative interference for recent fracture of the spine with signs of serious injury to the cord have been very poor. Either the patients have not been relieved, or the fatal outcome has been hastened, or the patients were improved after the operation. In this latter class of cases it has usually been an open question whether the same improvement would not have occurred if no surgical interference had been attempted. The worst results have followed operative interference for fresh fracture of the cervical spine. In appropriate cases an operation might be performed where the X-ray showed clearly that there was a pressure of bone threatening complete destruction of the spinal cord. Here the surgeon might attempt to relieve a destructive œdema or hæmorrhage into the cord, by means of incision of the cord, as suggested by the animal experiments of Allen. In general, however, the surgeon should be very conservative in his recommendation of operative interference. Where the X-ray shows undoubted bone pressure and there is considerable motor power left, an operation may be advised. It has been my experience, however, that it is best to delay surgical interference even in these patients.

There is a class of cases in which the symptoms of the cord lesion are not very marked for weeks or months after the injury, but sooner or later signs of serious and progressing interference with the cord functions appear. In other patients, the signs of a serious cord injury have cleared up to a certain extent, and then improvement has ceased. In both of these classes the X-ray shows that there is, due to the original injury or to new bone formation, marked narrowing of the spinal canal and, therefore, pressure on the cord, or a partial dislocation of the body or laminæ of one or several vertebræ, causing marked angulation of the cord. These patients can be enormously benefited by a laminectomy, with free removal of spinous processes and laminæ and exploratory opening of the dura. By this means a much narrowed spinal canal can be widened and a marked

Fig. 12. Examples of extramedullary spinal tumors successfully removed at operation.

angulation of the cord straightened out by allowing room for the dural sac to bulge backwards. In some of these cases, the prominence on the posterior surface of the body of a vertebra can be removed extradurally. The accompanying X-ray pictures and sketches (Figs. 5 to 11) show the conditions that are met with and the changes that are brought about by the decompressive laminectomy. Sometimes it is sufficient to remove the spinous processes and laminæ of the affected vertebræ so as to allow the cord in its dural sheath to bulge backward, but in most cases the dura should be incised and the cord examined. A localized cyst or a hæmatomyelia cavity may be found and laid open. If necessary, the dural sac should be carefully raised up and a prominence on the posterior aspect of a vertebral body removed. When this is done, there is often considerable venous oozing from the plexuses on the posterior surface of the vertebral body. The bleeding can be controlled by pressure with gauze packings. The results in these patients are very satisfactory. Improvement usually begins soon after the operation, as the following short histories will show:

CASE 1. *Compression of cord after old fracture dislocation of spine; laminectomy; steady improve-*

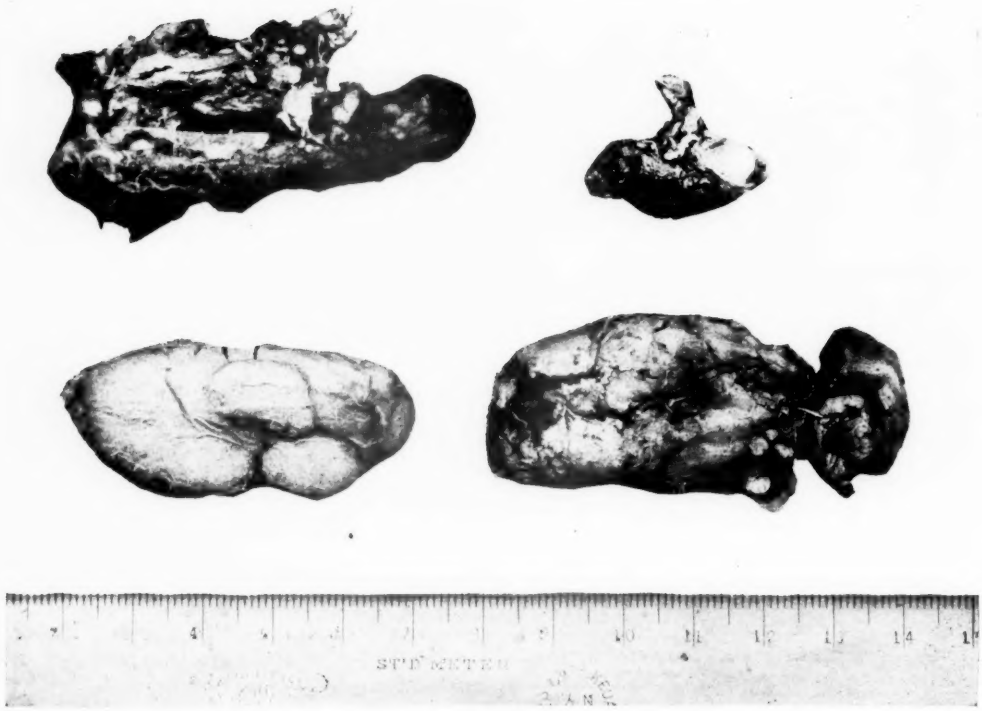

Fig. 13. Examples of intramedullary spinal tumors removed from the interior of the cord by the method of extrusion. (These tumors appear very large on account of the œdema which occurs during the extrusion.)

ment (Figs. 5 and 6). Pierre H., 27 years of age a private patient of Dr. Peterson at the Neurological Institute. Fell down elevator shaft five months before; unconscious for several days. Paralysis of right arm and leg and weakness of left side. After several weeks, some return of power in right leg, but increasing weakness of left arm and contractures in right upper extremity.

Physical examination.— Palpation of spine shows irregularity of fifth and sixth cervical spines. Marked atrophy of muscles of right upper extremity; weakness and spasticity of right and, less so, of left arm; spastic weakness of right lower extremity and slight of left one. Abdominal reflexes absent; knee and ankle jerks exaggerated, right more than left; double ankle clonus and Babinski. Diminution of all sensations up to level of C_4 area more marked on right side. X-ray shows that there is an old fracture and backward displacement of the fifth and sixth cervical vertebræ.

February 8th.— Laminectomy (Dr. Elsberg); removal of spines and laminæ of fourth, fifth and sixth cervical vertebræ; dura much thickened; incision of dura followed by escape of large amount of cerebrospinal fluid under pressure; cord much flattened and bent at a marked angle by prominence on posterior surface of body of fifth cervical vertebra. After removal of spines and laminæ, cord bulges backward, and angulation is straightened out. Suture of dura, muscles, fascia, and skin in usual manner. Duration of operation, 45 minutes; convalescence uneventful.

February 12th.— Abdominal reflexes have returned; slight return of sensation in left foot.

May 1st.— There has been constant and progressive improvement in both power and sensation; weakness of left arm and leg have disappeared; marked increase of power in left upper and lower extremity; patient walks about freely; great improvement in sensory disturbances.

Result. Very marked and steady improvement.

CASE 2. *Old fracture of spine with compression of cord; laminectomy* (D10, 11, 12, L1); *Great improvement* (Fig. 7). Laura L., 36, admitted December 26, 1911, to the service of Dr. Collins at the New York Neurological Institute. Fell from wagon 19 months ago and was in bed one week. Pain in back; pain and stiffness in left hip, followed

Fig. 14. Large tumors of the cauda equina, removed by laminectomy.

a few months later by weakness in left and then in right lower extremity. Now complains of cramps in both lower extremities and of weakness in both lower limbs, especially the left.

Patient is able to walk only by means of crutches. She has a large supporting splint on the left lower limb. Upper extremities are normal; both lower extremities very weak — the left so weak that the foot can hardly be raised from the bed; double drop foot.

There is hypæsthesia and hypalgesia over the third, fourth and fifth sacral areas on both sides, band of hyperæsthesia and hyperalgesia two inches wide over the right and left distribution of L_2 and L_3. Stiffness of back in lower dorsal and lumbar regions; tenderness of twelfth dorsal and first lumbar spines. X-ray shows old fracture.

December 28th.— Laminectomy (Dr. Elsberg). No irregularity of spine can be felt before operation. Spines and laminæ of tenth, eleventh and twelfth dorsal and first lumbar vertebræ removed; spine of twelfth dorsal has been fractured and points obliquely to the left. The dural sac has been pressed backwards by a marked prominence of the body of the first lumbar vertebra. When the dura is opened, the roots of the cauda equina are found much flattened and tightly stretched at an angle over a prominence of the posterior surface of the body of the first lumbar vertebra. There is a marked deformation of the spinal canal (Fig. 7). The attempt to remove the prominence of the body of the first lumbar had to be desisted from because of the profuse bleeding that ensued when the dural sac was raised and the body of the vertebra exposed. The removal of the spines and laminæ had allowed the roots of the cauda equina to bulge backward, so that the marked angulation had disappeared. Suture of dura muscles and skin.

Convalescence from the operation uneventful; gradual improvement in all of the symptoms. By the beginning of January, the patient was able to stand alone without her splint; one month later she was walking around freely with the aid of one cane. The band of hyperæsthesia had disappeared, and the perineal sensory loss was much less marked. Two months later, the patient was walking around without any support; she walked up and down stairs without trouble and was able to attend to her housework. The drop foot on the right side had disappeared; there was only slight weakness of the left side; power in the right lower extremity was normal; of left, was much improved. Can raise

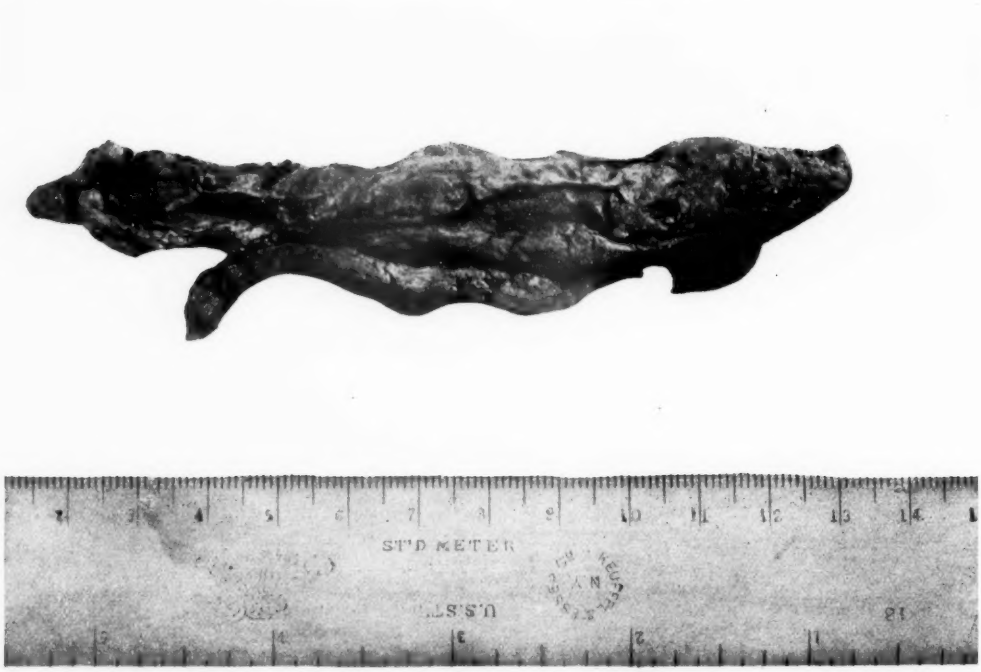

Fig. 15. Very large tumor of the conus and cauda equina, removed successfully at operation.

both feet from bed with ease; knee and ankle jerks still absent. The patient returned to her home in the South and has not been heard from since.

CASE 3. *Compression from cord of old fracture 18 years before; laminectomy; very marked improvement.* Mary G., 36 years of age, service of Dr. Bailey at the Neurological Institute (Figs. 8 and 9). (Reported by Dr. Bailey at the meeting of the American Neurological Association, 1911.)

At the age of 18, fell from back of mule, striking on her back. Except for some stiffness of the back, she was not apparently hurt and did not go to bed. Three days later, a prominence was noticed in the middle of her back, but, excepting for the fact that her back was somewhat stiff, she had no symptoms. Three months before admission, she began to have very severe aching pains in both of her legs, and had to go to bed on account of the pain.

Physical examination.—Marked weakness of both legs — cannot raise the left from the bed; the right only about six inches. All the muscles of both legs are atrophic, the left more than the right; knee jerks absent, jerks present, double clonus and Babinski. There is a marked deformity of the lumbar spine, a very prominent gibbus from twelfth dorsal to the fourth lumbar, most marked at the second lumbar spine. There is a complete loss of all three sensations over the third, fourth and fifth lumbar and first sacral areas on both sides, and a marked diminution of all sensations over the second and third sacral area. X-ray shows a destruction of the lower surface of the body of the first lumbar and upper surface of the body of the second lumbar vertebra, and some destruction of the bodies of the second and third lumbar vertebræ, and a large amount of new formed bone around the arches of the twelfth dorsal to fourth lumbar arches.

January 28, 1911.— Laminectomy (Dr. Elsberg); Spinous processes of third and fourth lumbar, and then successively of the second, first lumbar, and twelfth dorsal vertebræ removed. The removal was very difficult on account of the large amount of new-formed bone which bound together the arches of the vertebræ (Fig. 9). The cord with its envelopes was much compressed and bent at an angle; it seemed almost to be spitted on a prominence of the body of the second lumbar vertebra. The cord and cauda equina were bent at an angle (see diagram), and it was clear that they were compressed against the sharp shelf formed by the body of the second lumber vertebra. At this point, the inner surface of the dura was markedly congested and

had a shaggy appearance. Most of the new-formed bone was removed. Suture of the dura, muscles, fascia, and skin in the usual manner.

Convalescence uneventful; marked and rapid improvement.

March 7th.— Can raise both limbs freely from bed; can stand unsupported and can walk with some assistance; pain in thighs much less; almost all of the sensory disturbances have disappeared, and it is difficult to find any area in which there is any definite diminution in sensibility.

April 21st.— Discharged, relieved; all sensory disturbances have disappeared; back is still rigid; patient says that pain in thighs is much less. She now has good power in both limbs, and walks around without assistance; ankle clonus and Babinski have disappeared; knee jerks present on both sides. Still has some pain around the left hip.

CASE 4. *Compression of fourth lumbar root by torn ligamentum subflavum and fractured lamina of fourth lumbar vertebra. Laminectomy; removal of ligament; complete relief* (Figs. 10 and 11). Mrs. J. S. C., a patient of Dr. M. Allen Starr, 49 years of age. Thrown out of an automobile ten months ago; stiffness of back since that time. Six weeks ago, pain over the distribution of the fourth lumbar root on the left side, rapidly growing very severe. X-ray shows old fracture and thickening of arches of fourth and fifth lumbar vertebræ.

Laminectomy June 25, 1912 (Dr. Elsberg). Removal of spines and laminæ of third, fourth, and fifth lumbar vertebræ. Lamina of fourth is dorsally dislocated on the left side, the arch of the fourth vertebra having evidently been fractured and carried to the left. As soon as the left lamina of the fourth lumbar vertebra was removed, a firm mass bulged out of the spinal canal. The mass was about 2 cm. thick, and the manner in which it was forced out showed that it must have been under considerable pressure in the canal. The mass was excised and proved to be a much thickened ligamentum subflavum, which had evidently been torn loose at the time of the accident, ten months before. Part of the fourth lumbar root on the left side was then divided. Suture of muscles, fascia, and skin in usual manner. Duration of operation. 30 minutes.

Convalescence uneventful. Patient out of bed in two weeks, relieved of all of her pain. Complete recovery.

REMARKS

These four cases are given in some detail in order to show how very satisfactory are the results that can be obtained in these patients. The relief of the pain is often immediate, and improvement in sensory and motor symptoms very rapid. Fracture of a spinous process or lamina occurs much more often than we believe, and all the symptoms that the patient may have at the time of the injury may be a little pain and stiffness in the back. Only later, when the pressure on the cord gives rise to symptoms, does the real nature of the injury become clear. I believe that if all of the patients who are treated for a sprain or wrench of the back were subjected to an X-ray examination, an injury to the bony framework of the spine would be often discovered. It is remarkable, also, how often a serious injury to one or more vertebral bodies will give few symptoms.

I have operated upon several patients from whom no history of an injury to the back could be obtained, but in whom the X-ray findings and the operation demonstrated that there must have been, at some time or other, an injury to the spinal column. While in some of these patients the improvement occurs very quickly, in others it is very slow, and months or years will pass before most of the symptoms have disappeared. If the knee and ankle jerks are absent, it may take many months before they again appear. When there has been much new bone formation, the laminæ of the affected vertebræ should always be removed very freely, so that the intervertebral foramina are exposed. If this is not done, disagreeable root pains may persist. Often it is advisable to cut the most affected posterior root. The operator must always be certain that he has removed a sufficient number of vertebral arches so that the cord and its membranes can bulge backwards and any angulation be entirely relieved.

THE SURGICAL ASPECTS OF SPINAL DECOMPRESSION

In the paper by Dr. Bailey and the writer,[1] we have called attention to the remarkable effects that sometimes follow a laminectomy for symptoms of local spinal disease where nothing abnormal is found inside or outside of the dura, and where there is no increase of pressure. In that paper we suggested that the benefits that seem to accrue might be due to changes in the spinal circulation or might result from the entrance of air into the spinal canal. Since that paper was published, I have operated upon several additional

[1] Pearce Bailey and C. A. Elsberg, Spinal Decompression, J. Am. M. Ass., March 9, 1912, vol. 58.

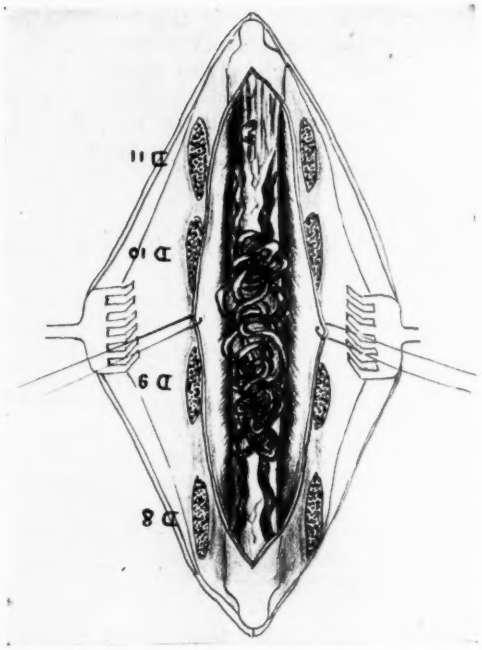

Fig. 16. Arteriovenous aneurysm of the posterior spinal vessels, giving the symptoms of a spinal tumor.

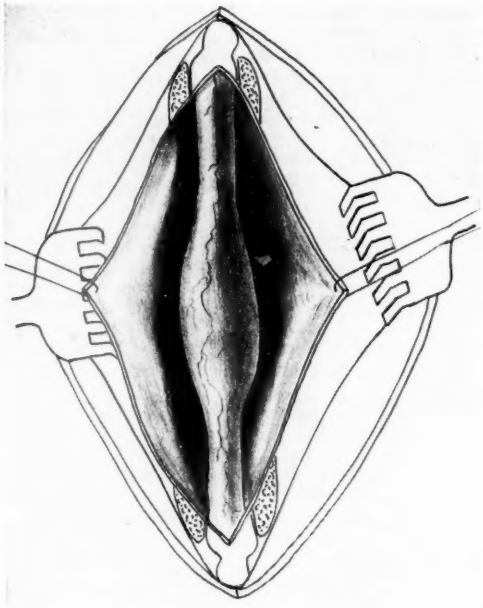

Fig. 17. The appearance of the cord in the case of Dr. L., with an intramedullary tumor of the cervical cord.

patients and have seen great relief from the symptoms, so that our conclusion is justified, that the opening of the spinal canal may, and often does, have a profound effect upon the spinal cord. This may act beneficially upon some spinal diseases whose nature is as yet not understood and whose pathology is unknown. I have recently operated upon a patient with a spinal disease, who had been incontinent for a number of months. Nothing was found at the operation to explain her symptoms, but she recovered control of her bladder within a short time of the operation.

There is a peculiar disease of the roots of the cauda equina which has not, as far as I have been able to determine, been described. The symptoms which the patients present are very like those of tumor of the cauda equina. Although nothing is found at the operation that can be relieved by surgical means, all of the patients improved very much after the operation, and the result can only be ascribed to the laminectomy. These cases will soon be described in detail by Dr. Kennedy and the writer.

INTRAMEDULLARY AND EXTRAMEDULLARY SPINAL TUMORS AND THEIR REMOVAL

In my series of twenty-two cases of spinal tumor, four were extradural and eighteen intradural. Of the latter, eight were cervical, five dorsal, two lumbar, and seven affected the conus and roots of the cauda equina. Of the intradural tumors, five were intramedullary and thirteen extramedullary (Figs. 12 to 21).

The removal of an extramedullary tumor of the spinal cord is one of the most satisfactory of all operations. If the tumor has been correctly localized and the proper spines and laminæ have been removed, the operation can usually be done in half an hour, or less, and the dangers of the operation are very small. It is always advisable to remove at least two or three spines and laminæ, so that the tumor is well exposed. The operation can usually be done in one stage, excepting when the growth is in the upper or middle cervical

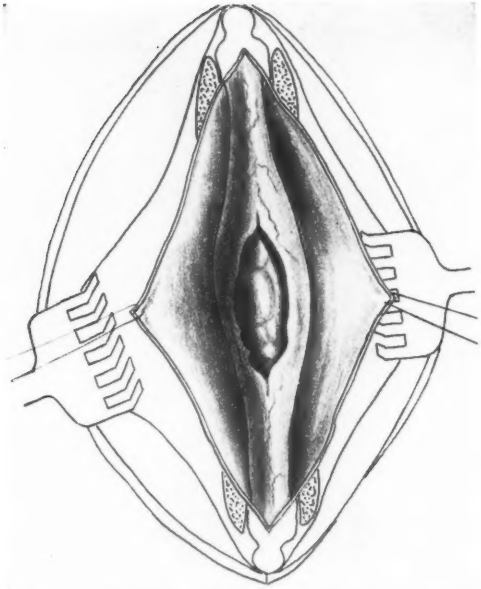

Fig. 18. Beginning extrusion of the tumor in the case of Dr. L., after incision of the posterior column of the cord over the prominence of the growth.

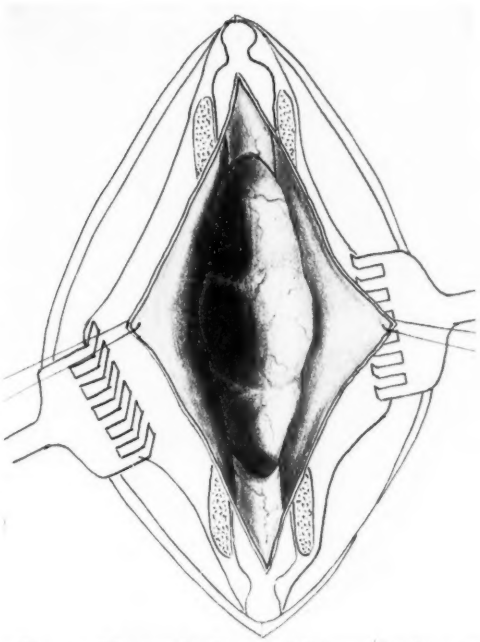

Fig. 19. The completely extruded tumor in the case of Dr. L. The tumor was removed with ease, and the patient has recovered to a very marked extent. (Large size growth due to œdema, which occurs during extrusion.)

region. In these latter cases, it is often preferable to stop as soon as the tumor has been exposed, so as to allow a readjustment of pressure conditions on account of the proximity of the medulla.

The removal of giant tumors surrounding the roots of the cauda equina (Figs. 14 and 15) can also be made more easy and safe if the actual removal of the tumor is delayed for a few days or a week. These tumors surround the roots of the cauda, and it is often difficult to free the roots without the infliction of considerable injury to one or the other of the roots. If the dura is left open until the second stage, the tumor will be found to be partly extruded from the spinal canal and from the roots of the cauda.

Intramedullary tumors must always be removed in two stages, by the extrusion method, as described by Dr. Beer and myself.[1] I have elsewhere written in detail regarding the principles of intramedullary surgery — procedures which I hope will much extend the field of spinal surgery. Based upon anatomical and histological considerations, I have shown that it is both feasible and safe to incise the cord in order to allow of the extrusion of localized intramedullary growths, to empty cysts of the cord, and for intramedullary decompression in irremovable tumors, syringomyelia, etc. By the method of extrusion (Figs. 17 to 19), the separation of a tumor from its bed or cavity in the cord is left to the processes of nature. These processes are based upon pressure conditions in the cord. Nature can accomplish the end desired with far less danger of injury to the delicate structures of the cord than the most gentle manipulations of the operator. Therefore, the surgeon must leave to nature the actual extrusion of the growth; by the free removal of spinous processes and laminæ and by a properly placed incision in the cord substance, he must make conditions as favorable for the extrusion of the tumor as possible. Finally, when the tumor has been extruded

[1] Elsberg and Beer, Am. J. M. Sciences, November, 1911.

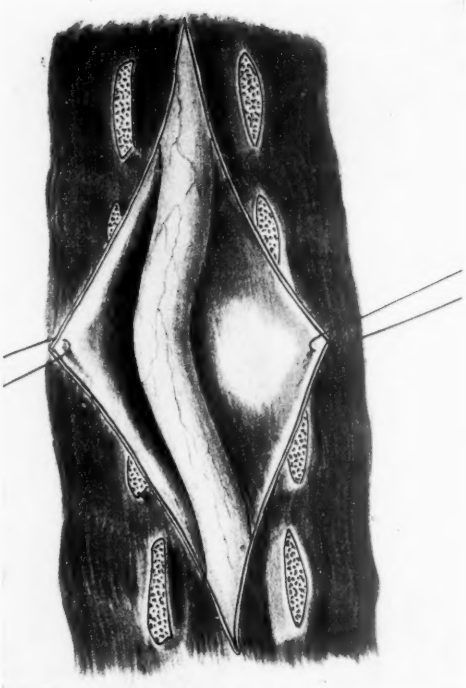

Fig. 20. An extradural tumor of the spine. Louis H. The dura is open and retracted, showing dislocation of the cord by the growth which is causing a bulging of the dura.

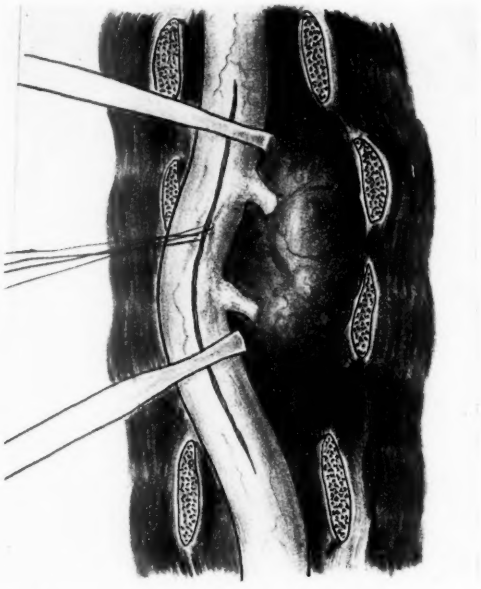

Fig. 21. Louis H. Dural sac retracted to show the tumor in its bed in the spinal canal. In this patient, the X-ray picture showed a marked enlargement of the canal at the level of the tumor, due to absorption of the bone.

from its bed in the cord, he must remove the tumor without injury to the delicate structures which surround it.

When the tumor lies outside of the cord, either under the pia-arachnoid or under the dura, its removal is usually accomplished with ease. Many of the growths lie on the posterolateral aspect of the cord, so that when the dura is incised and retracted the tumor is raised from the cord. If it lies under the pia-arachnoid, these membranes will have to be divided before the tumor can be extracted. If the tumor lies on the anterolateral aspect of the cord, one can usually expose it very satisfactorily by dividing one slip of the ligamentum denticulatum. The ligament is then grasped with fine forceps and drawn backward until the growth has been removed. If a tumor on the anterior surface of the cord is of small size, the division of one slip of the dentate ligament will allow the cord to be drawn out of the way and rotated sufficiently to permit of the removal of the growth. Sometimes, however, it is necessary to divide one posterior root before the tumor can be well exposed.

It is not advisable to make a careful examination of the cord after the tumor has been extracted, because these flattened cords are very soft and easily injured.

If a posterior root is found stretched over the tumor, especially if there have been severe root pains referred to that nerve before the operation, the root in question should be divided. Disagreeable root pains sometimes persist in a posterior root which has been long pressed upon by a tumor.

The dura must always be opened, even if an extradural tumor has been found, for there is sometimes an intradural growth as well. Palpation through the dura is an uncertain procedure, and a small intradural tumor on the anterior or anterolateral surface of the cord might easily be missed.

SUBCUTANEOUS RUPTURE OF THE DIAPHRAGM AND POSITIVE PRESSURE (MELTZER)[1]

An Experimental and Clinical Study

By E. C. RIEBEL M. D., Chicago
Instructor in Surgery, Northwestern University Medical School; Surgeon to People's Hospital; Associate Surgeon to Wesley Hospital

ON September 8, 1910, the following case came under my observation: A boy about ten years of age was brought to People's Hospital with this history: A wagon loaded with gasoline cans passed over his left leg and side of chest, almost cutting off his ear, while the boy was lying prone on the ground. I saw him about two hours after the accident. His facial expression was anxious; pulse 116, rapid, thready, and irregular. He was sitting up in bed, unable to lie down. Had vomited shortly after entering and vomited again after my arrival. Muscular defense had been noted upon his arrival and was not well marked. The abdomen was distended in the epigastric region; the lower portion of the chest wall seemed broader than normal. There was considerable tympany over the epigastrium; percussion over the chest elicited tympany as far as the level of the fourth rib. No breath sounds were heard over the left chest. The heart tones were very indistinct and the apex beat could not be located. The breathing was jerky, as if due to fixation of the diaphragm, the same as during a severe gall-stone attack. He complained of pain "about the heart." The epigastrium was tender. The liver dullness was almost obliterated. Urine had been voided and was normal. There was no dullness in the flanks. The skin over the epigastrium felt somewhat emphysematous. The symptoms pointed strongly to a rupture of the diaphragm and that of a hollow viscus. The boy was etherized and an incision made in the median line from ensiform to navel. The breathing became more regular after complete anæsthesia had begun. When the peritoneum was reached, this bulged out as if under pressure. Upon incision there was a hissing sound; some loops of distended small intestines slipped out of the wound. There was no blood or gastro-intestinal contents in the abdominal cavity. The transverse colon was in the place commonly occupied by the stomach. With difficulty I located the pylorus and, following this, found almost the entire stomach in the pleural cavity. The entire left half of the diaphragm, as far back as the costal angle, had been detached from the ribs at right angles to its fibres. The opening admitted four fingers widely spread. Upon withdrawing the stomach from the chest cavity the boy's respiration became much embarrassed and very shallow. Direct heart massage was practiced through the tear. The left ventricle contracted vigorously for some time, but respiration ceased and could not be re-established. Inspection revealed the stomach and intestines as well as parenchymatous organs uninjured. A post-mortem was not held.

A search of the literature shows that the number of reported cases is not great, while one rarely finds a case which recovered. The scarcity of published cases does not indicate that the occurrence of this condition is so rare, for a personal communication with a number of surgeons engaged in accident and emergency work revealed the fact that each one had one or more of these cases. I wish to draw attention to the sharp difference between open and closed diaphragmatic wounds. The former are rarely associated with immediate prolapse of abdominal organs, excepting the omentum, because as a rule the opening is too small, operative interference is usually successful, while in the subcutaneous tears of the diaphragm, which are usually large, a prolapse is the rule, and the outcome, with or without operation, as mentioned above. Whatever the individual surgeon's opinion may be regarding the use of differential pressure in operative pneumothorax, whether necessary or not, I have the conviction that if it could have been employed in this case it might have gone to a happier termination. A number of experiments were undertaken, to study both the physiological side of subcutaneous rupture of the diaphragm, and to suture a diaphragmatic wound under differential pressure to ascertain its advantages, if any. The admirable simplicity of Meltzer's insufflation apparatus commended its use, hoping that in its original form it might be used in the human in a case of emergency without much trouble and expense.

The air supply was furnished by an electric pump, the air passing through a Wulff bottle one half full of ether. A manometer was placed in the circuit. A soft rubber catheter, size 21, French,

[1] Read before the Chicago Surgical Society, November, 1911. (See discussion, p. 223.)

served as tracheal catheter. The tip of the catheter was cut off and the edges trimmed. At times I used a second Wulff bottled filled with cold water to moisten and cool the air before passing through the ether. A general test showed that the apparatus worked well as far as maintenance of differential pressure was concerned. The middle lobe of the right lung was resected in one dog with good success; in another the sternum was removed in toto, exposing both pleural cavities. The dog was kept alive and breathing regularly under a pressure from 10 to 20 mm. for two hours. The experiment was discontinued for external reasons and could have been kept up much longer.

The advantages of this method for anæsthesia I merely emphasize in passing, as it has been used by Elsberg and others in many cases on the human subject, irrespective of its pressure features.

Nine dogs were used for the experiments: two of these for the study of the results of rupture of the diaphragm only, the remainder for suture of the lesions produced. The incisions in the diaphragm were made uniformly on the left side in the muscular portion of the diaphragm, at right angles to the course of the fibres and large enough to admit three fingers. In one dog (No. 7) an abdominal opening was made and the diaphragm incised. Insufflation, which had been employed up to that time, was discontinued after the hæmorrhage had been stopped. There was a prolapse of abdominal viscera. Almost immediately respiration ceased, blood pressure (Riva Rocci) fell to zero, and insufflation had to be recommenced. This proved successful, blood pressure rose to 70 mm.; the dog, however, died after a few minutes. Both lungs were pink and showed no signs of œdema. The right ventricle was distended. In another dog (No. 8) the chest was opened by a quadrilateral flap without insufflation; respiration became quite shallow and finally ceased. The heart continued to beat for a while, then stopped. At this time insufflation was instituted and the dog revived. The diaphragm was incised, the stomach allowed to prolapse into the pleural cavity, and the flap closed by two layers of sutures. Blood pressure ranged from 75 mm. to zero before insufflation; afterwards, at the close of the operation, from 98 to 90 mm. The dog recovered from the anæsthetic completely, but died somewhat suddenly one hour later. In the other seven dogs used for suture experiments, insufflation was used throughout. After incision of the diaphragm the proximal portion of the muscle was pushed over to the right side and the blood pressure taken before, during, and after the experiment. No appreciable changes were noted in the blood pressure. The insufflation pressure ranged from 10 to 25 mm. during the suture of the diaphragm and was increased to 35 mm. while closing the wound to drive out all the air. Respiratory movements were almost absent, and this state of comparative apnœa greatly facilitated the suturing, as the diaphragm hardly moved. It was possible to introduce a continued suture, closing the rent in the diaphragm completely. In those dogs where the tear was produced through the abdomen I placed it dorsally, and found the mobilization of the diaphragm, by resection of the ninth rib at the junction with its cartilage and resection of the tenth rib in the axillary line (Lannelongue-Willy Meyer), quite advantageous to bring the diaphragm into a position of inspiration and thus render the somewhat inaccessible tear more superficial. Here again the absence of diaphragmatic movements proved to be of great assistance in thorough and rapid suture. I repeated this mobilization of the diaphragm in a couple of cadavers and found it satisfactory. The transpleural route offered, of course, less difficulties in suturing. It was employed in three of the dogs. The chest was opened by a rectangular flap containing bone, muscle, and skin and comprising two ribs. It was closed in two layers. In the remaining four dogs the abdominal route was chosen. None of the dogs died from the immediate effects of the operation. Insufflation without ether was usually continued from 5 to 10 minutes after the conclusion of the operation and seemed to have a highly stimulating effect upon the animal, materially hastening its recovery from the anæsthetic, also obviating nausea and vomiting. Morphia was employed in the earlier experiments, but later discarded to avoid any influence upon the respiration and blood pressure. The experiments were carried on during very hot weather; asepsis was also but partial. This interfered much with ultimate results. The blood pressure usually rose when the diaphragm was incised through the abdomen.

Before attempting to draw any conclusions from these experiments it must be admitted that they were rather incomplete and limited in number. Again the element of severe traumatic shock so constantly present in this class of injuries, as well as the frequent trauma of other organs, was absent. The anatomical and functional differences between the diaphragm of man and that of the lower animals does not permit of direct application of observations. The method of fixation differs in the dog, inasmuch as the pericardium and diaphragm are not united, and the heart does not depend upon the diaphragm as much in this animal as it does in man. Functionally it has not the importance for the circulation which it possesses in man, because, owing to the horizontal posture of the animal, a relatively small force is required to maintain the general circulation and promote the re-

turn of the blood from the abdomen. These advantages are offset by the frequent communication between the two pleural cavities in the dog. The normal as well as the pathological physiology of the diaphragm still offers many problems. I am indebted to the splendid work of Hans Eppinger for much information upon this subject, and shall quote it freely:

The following anatomical considerations are of importance. In man the central tendon supports the heart, while the fibrous pericardium may be regarded as the fascial insertion of the muscular diaphragm. Through this fibrous pericardium and its continuation upward into the sheath of the great vessels, which in turn is continuous with the middle layer of the deep fascia of the neck and the carotid sheath, the diaphragm is closely connected with the great vessels. From beneath, the diaphragm is supported by the abdominal viscera, themselves kept in place by the tonic contraction of the abdominal muscles. More specifically, the inferior supports are the liver and its falciform, coronary, and lateral ligaments. Further supports are the inferior vena cava, through its attachment to the liver, and the stomach and intestines, which constitute an air cushion on which the solid viscera, especially the liver, are supported. The diaphragm serves both as tractor as well as a compressor. It assumes its rôle of respiratory function only after birth; serving as a circulatory muscle during intrauterine existence.

The diaphragm plays the most important rôle in maintaining equilibrium within the thoracic cavity. The tonus and the active force of the midriff antagonize the elastic force of the lung and the cohesion of the pleural layers. Both forces keep up the balance between elasticity of the lung, negative intrathoracic pressure, the tension of the diaphragmatic fibres and the other muscles surrounding the thorax. During moderate contraction of the diaphragm the enlargement of the thoracic cavity is caused chiefly by rendering the complementary space larger, while with deeper inspiration the centrum tendineum is considerably depressed. Excessive contraction of all the muscular fibres of the diaphragm may produce a horizontal position of this structure. Occasionally these contractions may become so strong that there is contraction at the very point of origin, with narrowing of the lower thoracic aperture. Normally several factors prevent this — amongst these, mainly, the costal inspiratory muscles and the increase in intra-abdominal pressure. These may not only regulate but overcorrect the contraction and produce a widening of the lower thoracic aperture.

The importance of intra-abdominal pressure in this direction has been proven by Duchenne's experiments. Phrenic nerve stimulation causes spreading of the lower ribs with closed abdomen, which is changed to retraction as soon as the abdomen is opened. The position of the diaphragm changes with posture, and this mainly depends upon resultant changes in intra-abdominal pressure. The influence of the diaphragm upon the circulation has been alluded to before. From important observations the conclusion may be drawn that the diaphragm is one of the most important supporters of cardiac function as well as of the circulation. This function can be observed throughout the animal series, from the lowest to the highest. Keith points out the useful arrangement of the muscular bundles in relation to the heart and the inferior vena cava, whereby the right auricle is brought nearer to the blood reservoir with each contraction, facilitating its more rapid repletion. The diaphragm is likewise a most important factor in the hepatic return circulation. It has been proven experimentally that the volume of the heart beat increases with each contraction of the diaphragm. The main function of the diaphragm may thus be summarized to be the following:

(*a*) Barrier between thoracic and abdominal cavities.

(*b*) Ventilation of the lung.

(*c*) Regulation of abdominal circulation.

In view of this fact one might expect an injury to the diaphragm to be followed by interference with the ventilation of the lung and disturbances in circulation. As the greater portion of respiration is internal, depending upon an exchange of gases between

DATE	NO.	ROUTE	POSITIVE PRESSURE	ANÆSTHETIC	RESULT
6–23–11	1	Chest	Insufflation	Morphin, ether	Death after 1 week Infection
6–30–11	2	Abdomen. Transverse incision. Resection of eighth, ninth, and tenth ribs	Insufflation 25 mm. and 30 mm.	Ether, morphin	Death after 4 days Infection
8– 8–11	3	Abdomen. Resection of cartilage of eighth and ninth ribs	Insufflation 10 mm. and 35 mm. 25 mm.	Morphin, ether	Alive and well
8– 8–11	4	Chest. Flap consisting of sixth, seventh, and eighth ribs	25 mm.	Ether	Alive and well
8–11–11	5	Chest	25 mm.	Ether	Death 4 days later.
8–11–11	6	Abdomen. Resection of ninth rib at junction with its cartilage. Resection of tenth in axillary line	25 mm.	Ether	Alive and well
8–18–11	8	Chest	25 mm.	Ether	Tore wound open with teeth. Infection. Death after 3 days.
8–21–11	10	Abdomen	25 mm.	Ether	Death 3 days later from infection

blood stream and tissues, the ultimate result would be insufficient aeration of the entire system. Under ordinary circumstances this is counterbalanced by other forces which maintain equilibrium. In our experiments positive pressure permitted dislocation of the thoracic viscera, after incising the diaphragm to quite a degree, without evil consequences. In open wounds of the diaphragm without prolapse, the existing pneumothorax equalizes, perhaps, the deleterious effects of positive intra-abdominal pressure. In subcutaneous rupture conditions are different. The action of the diaphragm, though impaired, will aspirate the viscera into the pleural cavity, creating there a condition of varying, though more or less positive, pressure as we find it in the abdomen.

Why do these patients react so violently to the creation of an operative pneumothorax? One would rather expect that the entrance of air would equalize the pressure. A common pneumothorax is no longer feared by surgeons. Differential pressure would not be required to offset the entrance of air, but rather to maintain equilibrium during handling of thoracic organs, causing more or less violent disturbances in equilibrium. The entrance of air into the chest cavity is followed by a collapse of the lung. This may be partial or complete according to the size of the aperture. It is complete if the aperture is greater than the diameter of the largest bronchus. In a normal chest cavity pneumothorax may not be associated with any symptoms whatsoever, as the following case well illustrates:

A colored girl received a razor cut, severing the third, fourth, and fifth left costal cartilages at a little distance from the sternum. The internal mammary artery was not injured. The wound was pulled apart by retractors; one could see a completely collapsed lung in the upper portion of the thorax. Neither heart nor lung were injured. The wound was closed; no special symptoms were observed during examination. Dyspnœa was very slight. A complete recovery followed.

This truly was a complete collapse of the lung, but not a pneumothorax, if we are to express by that term the alarming train of symptoms; other factors must evidently enter. These have been attributed to insufficient fixation of the mediastinal pleura, which flutters to and fro in respiration (Murphy and Garré), kinking of the larger

bronchi by displacement of the mediastina (Rehn), circulatory disturbances due to kinking of the great vessels (Friedrich), and a deficiency of the lung ventilation (Tiegel); prolapse of stomach or intestines produces conditions which closely resemble those enumerated in closed or tension pneumothorax, so that one could speak of an internal pneumothorax if this term was not misleading. The entry of air from without must necessarily aggravate the symptoms, and if toleration is exceeded, that is, the thoracic equilibrium disturbed, with fatal results due to insufficient internal respiration.

There are undoubtedly other factors besides mechanical ones, and they may not unlikely be found in an increased sensitiveness of the visceral pleura, as experienced by Lewis and Capps. These observers found that touching a diseased visceral pleura with a needle during aspiration may lead to instantaneous death. Their observations showed the cause to be found in the sympathetic nervous system. How much the element of shock, always present in subcutaneous injuries of the diaphragm, adds to increased vulnerability of the sympathetic system is not easy to determine.

Diaphragmatic herniæ have frequently been operated upon with success long before the advent of pressure apparatus. These successes must be attributed to conformation of the chest contents to the alteration; for as a rule these cases are of more or less long standing, and here a pneumothorax would not produce the fatal disturbances as in the acute cases under consideration. It has been argued that the transpleural approach in diaphragmatic rupture will give better results; that the operative pneumothorax will counterbalance position pressure in the thoracic cavity. The few cases, however, which recovered after operation have been laparotomized. The variations in the character of the mediastina must be taken into consideration. In the child they are much thinner than in the adult, and the thickness varies greatly in different individuals.

As stated before, subcutaneous ruptures are not as rare as one would believe. It is surprising to find, in Lachner's compilation of 266 cases of diaphragmatic hernia, the following relations:

Open	37 due to stab wound	Total 31
	14 due to gunshot wound	
Subcutaneous	35 due to falls from a great height	Total 45
	7 due to burying accidents	
	3 due to compression of the thorax	

This furnishes positive proof that the condition is more frequent than would appear at first glance and should be looked for in examination of persons suspected of having sustained a subcutaneous trauma of the chest or abdomen, during operation as well as before. It is not necessary to dwell here again on the disastrous consequences of this injury, either immediate or remote, as they are well known. In surgical text-books this form of subcutaneous injury receives but scant mention. The cases of Suter and Walker are about the only ones where operation was undertaken for the previously diagnosed condition. The mechanism of diaphragmatic rupture is not uniform. The commonest is a rise of intra-abdominal pressure, transmitted through a medium of gas and fluid, which pushes the diaphragm upward and stretches it beyond the point of endurance. The rupture may be the result of a forcible straightening of the ribs and pushing up of the thorax, such as occurs in a more lateral compression of the lower chest and abdomen. An intermediate between rupture and stab wounds is represented by perforations of the diaphragm by a fractured rib. This is uncommon. The increase in intra-abdominal pressure causes at the same time forced expiration, and with it a minimum of intrathoracic pressure. The diaphragm is deprived of its brace above, and ruptures.

The most common causes of increased intra-abdominal pressure are run-overs, burying accidents or falls from a height. It is an interesting fact that this increased tension may work in two directions, either upon the diaphragm or upon the pelvic floor; if very excessive it may attack both (Kirschner's case). The diaphragm generally ruptures at its outer margin, in the muscular portion. Obviously the rupture occurs more often on the left side (5 to 1), because the compact and non-yielding liver receives and breaks the

force on the right side, thus protecting the diaphragm. Rupture as the result of muscular contraction of the diaphragm is exceedingly rare. König asserts that this will hardly occur without previous degenerative changes. The tear in this variety affects the centrum tendineum. Sutur cites three cases from the literature, reported by Desiret de Fortunet (Lyon méd., 1886). One was that of a woman who sustained a rupture of the midriff during labor; the second, of a man during a violent attack of vomiting, produced by an emetic; while the third suffered the same injury during an attempt to hold up a heavy barrel. These injuries took place during forced inspiration, while the traumatic variety takes place during forced expiration. Malgaigne is of the opinion that ruptures of the muscular portion occur during expiration, those of the central tendinous part during inspiration. The symptoms of diaphragmatic rupture depend largely, if not altogether, upon the prolapse of abdominal organs. A small tear without prolapse will not present any diagnostic signs. The so-called classical symptoms and signs might conveniently be grouped under three classes:

(*a*) *Those due to insufficient air supply.*
Excessive dyspnœa, orthopnœa.
Rapid, irregular weak pulse.
Anxious facial expression, amounting at times to a risus sardonicus, as mentioned by Percy, a French physician.

(*b*) *Those connected with the displaced organs.*
Vomiting, due to traction on the mesenteric attachments of the displaced viscera or by actual interruption of the blood supply.
Muscular defense as a consequence of a lesion of the peritoneum.
Physical signs.
Tympany over the chest, amphoric breathing, succussion or gurgling sounds over the chest.
Widening of the chest.
Distention of the epigastrium.

(*c*) *Symptoms referable to injury of the diaphragm.*
Jerky respiration.
Pain on forced inspiration or coughing.

(*d*) *Referred symptoms.*
Pain in the shoulder, due to irritation of branches of the phrenic nerve.

General symptoms of a severe trauma, such as shock, are rarely absent; associated visceral lesions may overshadow the symptoms of diaphragmatic rupture to a large degree. It is hardly necessary to state that, with the exception of actual physical findings of prolapse, the remainder of the symptoms are merely suggestive.

SUMMARY

1. The diaphragm in man has an important influence upon the heart's action, by its anatomical relation to the heart and pericardium.

2. It is an important factor in the circulation by aiding venous return, especially from the abdominal cavity.

3. It plays an important part in maintaining equilibrium in the thoracic cavity.

4. Rupture of the diaphragm must needs be followed by serious disturbances in internal respiration and in the equilibrium within the thoracic cavity.

5. The inevitable prolapse of abdominal organs following subcutaneous rupture still increases this condition, frequently producing a state of positive pressure in the thoracic cavity.

6. The use of differential pressure is absolutely necessary to overcome these factors.

7. It will insure better results, in these cases, permitting furthermore the choice of abdominal or transpleural route or both as the occasion requires.

8. The character of pressure, whether positive or negative, is of little consequence, but the method of Meltzer is simple and can be used anywhere.

9. In cases of suspected subcutaneous rupture of the diaphragm, insufflation should be employed with low pressure (10 to 15 mm.) before operation, to overcome the deleterious effects of disturbed intrathoracic equilibrium.

CASE 1. Woman, 40 years old; fell from wagon, then run over. Several ribs broken on each side of the chest. Drunk. No sign of shock. No

vomiting. No dyspnœa. Death on following morning. Post-mortem: Fracture of third to eighth ribs on right side; fourth to eleventh ribs on left side. Left pleural sac contained stomach, spleen, transverse colon, and several feet of small intestine. Left lung was collapsed. The left dome of the diaphragm was completely torn across. Lesion not suspected ante-mortem.

CASE 2. Woman, 61 years of age. Wheel of van passed over the lower part of the chest. Discharged from hospital, at end of seven days, apparently well. Attended to house duties, but never seemed well since the accident; occasional attacks of breathlessness. Ninety-one days after accident, was out during the whole morning, but, on returning home, said she did not feel well and went to bed. At 6 P. M. she was given a large quantity of soda water, and immediately afterwards she vomited and became unconscious. She did not rally, and died three hours later.

Post-mortem: The left pleural sac was almost filled by the enormously dilated stomach. The lung was very small and was flattened against the left side of the spine, while the heart was so far dislodged as to lie entirely to the right of the middle line. The left side contained, also, the spleen and three feet of small intestine. The left dome of the diaphragm was completely torn across from front to back; while the viscera entering and leaving the chest were tightly strangled by the sharp cicatrized edges of the rent. There was no injury to the chest wall or to any other part of the body. Death would appear to have resulted from acute distention of the stomach by gas derived from the effervescent draught.

CASE 3. Henry M., age 50, fell July 2, 1906, twenty feet, striking on occiput; became unconscious. After three hours brought to Cook County Hospital; semi-conscious. Odor of alcohol on breath. Pulse 68, weak. Respiration 20. Temperature 98°, rectal. Scalp wound 5 cm. long over occiput, no depression of bone. Pupils equal; no paralysis. Patient rapidly gained consciousness. At first no abdominal signs were present. Not tympanitic or rigid. As consciousness returned, pain became intense in epigastrium. Much nausea, but unable to vomit. Abdomen grew rigid. Tympanitis came on quickly. Great dyspnœa and pain on inspiration. Urine negative. The left chest was hyperresonant, the heart being pushed to right. It was evident that the lung was collapsed and that air had taken its place. Cyanosis and dyspnœa increased, and in eight hours the patient died, before operation was deemed possible.

Post-mortem. Brain negative. The peritoneal cavity contained a large amount of stomach contents. The stomach was ruptured near its cardiac end on the anterior wall and greater curvature. The diaphragm was ruptured into the left pleural cavity with a laceration admitting the hand. Through this orifice a large amount of small intestine had been forced, forming a traumatic hernia nearly filling the side of the chest, thereby causing the tympanitis, resonance and great dyspnœa, possibly also embarrassing the heart. The pericardium was not torn.

CASE 4. E. W. Andrews (Surg., Gynec. & Obst., 1907). Rupture and hernia of diaphragm. Laborer sat on ground, with extended legs, leaning against a pile of boards. The pile collapsed and fell upon the man. He was found, knees touching shoulder, head between knees, unconscious. Brought to hospital 4½ hours later in collapse. Strong man, 28 years old. Temperature 36°. Complains of dyspnœa and pain in left chest. No fracture of the ribs. Tympany and percussion over left chest from clavicle downward. This obscured cardiac dullness completely. From seventh rib downward to ninth rib absolute dullness, passing from sternal line into the region of splenic dullness. Pulse 68. Abdomen soft, not rigid or sensitive to pressure, except slightly in region of stomach. Heart tones pure, regular, weak. At 10 P. M., somewhat better. Temperature 37°. Dullness had ascended to sixth rib. At 4 A. M. vomiting for the first time. Vomited repeatedly. Died at 7 A. M. during severe vomiting spell.

Post-mortem: Intestines slightly injected. Beneath left costal arch a portion of omentum two fingers wide. Stomach not visible. Beneath left costal arch is a tumor of the size of a child's head, covered by the transverse mesocolon. Strong traction upon the omentum and organs situated below is of no avail. Omentum tears, but cannot be delivered. Exploring hand glides into pleural cavity without resistance. Air enters simultaneously. Pleural cavity filled with two thirds of much distended stomach, the middle portion of the transverse colon (but little distended), the omentum and the spleen. Stomach and colon show a place where constriction has taken place; the furrow is two fingers wide showing suggillations. Left dome of diaphragm has a tear 12 cm. in length, beginning anteriorly in mammillary line passing sagittally to dome and ending posteriorly at the middle of the twelfth rib. The gap in its centre measures about 4 cm. Thoracic and abdominal cavities contain about a cupful of blood. If abdominal organs are released they slowly glide back into the thoracic cavity. No other injuries in abdominal organs.[1]

CASE 5. Miner. Buried under masses of ore. Unconscious at first. Recovered soon. No vomiting. Violent pain in gastric region. Pulse small, rapid. Hæmatoma over left chest anteriorly. Sixth to tenth ribs fractured, posteriorly and below; slight dullness over lungs. Urine normal, later bloody. Great tendency to cough. Later vomiting. Pain over stomach more violent. Respiration very rapid, shallow — forty per minute. Pulse rapid, at times impalpable. Great thirst. Death after eight hours.

Post-mortem: Two thirds of stomach in left thoracic cavity; left lung displaced upward; the

[1] Weischer, Zentralbl. f. Chir., 1900.

heart displaced backward. Superficial tear in stomach. Intestines much distended; mesentery ecchymotic. One pint of blood in abdominal cavity. Spleen normal. Tear in diaphragm leading directly into pericardial cavity; another tear 3 cm. from attachment of diaphragm to ninth rib. Heart intact. Lung tissue normal. Tear of diaphragm on right side. Eight liver ruptures distributed over convexity. Rupture of the right kidney, also left kidney; lower one third almost detached.[1]

CASE 6. Fireman. Buffer accident. Unconscious. Temperature normal. Pulse small and rapid. Dyspnœa. No respiratory sounds over left chest. Swelling in left lumbar region between eleventh rib and iliac crest. Blood in urine. Czerny incision to expose kidney. The diaphragm is found to be torn from its attachments in the axillary line to the extent of 18 to 20 cm. Pericardium and lung are visible. Anterior portion of twelfth rib is fractured. This is removed. Upper one third of kidney torn off. The wound in the diaphragm is closed in such a manner that the inner margin of the diaphragm is attached to the thoracic wall by interrupted sutures. Some pneumonic symptoms; exudation; recovery. Examined one year later; vesicular breathing over both lungs. General condition apparently normal.[2]

CASE 7. Man, 70 years old; tried to evade a kicking horse; fell on his back. A wagon grazed the right chest and lumbar region. Lips cyanotic. Pulse 124, respiration 40. Some emphysema. Third and fourth ribs fractured three fingers' breadth from left sternal margin. Tympanitic sound anteriorly on both sides. No heart dullness to be made out. Dullness in flanks. Two days later, hiccough, vomiting, pulse 130, pains in chest. Temperature normal, no sleep. Marked vomiting. No bowel movement. Posteriorly, on left side, metallic sound. Loin dullness begins at fourth rib. Absence of cardiac dullness. Less vomiting on fourth day. Pulse 120. Exitus on tenth day.

[1] Bergmann, Zentralbl. f. Chir., 1900, Bd. 27, p. 1206.
[2] Suter, Beit. z. klin. Chir., Bd. 46, 1905.

Post-mortem: Rupture of diaphragm in anterior portion on the right side. Tear occluded by omentum. Both lungs lacerated by fractured ribs.[3]

CASE 8. Girl 20 years old. Buried under a large load of sand, covering the lower portion of the body. Large tear in genital region on the right side, from mons veneris to anus. Exitus after a few hours.[4]

Post-mortem: Rupture of diaphragm. Prolapse of stomach and intestines.

CASE 9. Laborer thrown to ground by falling tree. Twenty hours later: grave shock. Pulse 145, soft, thready; severe dyspnœa. Violent pains in left chest, bloody sputum, fæcal vomiting, nausea. Tympanitic note over base of lung, amphoric breathing, succussion sound. Apex beat two inches to right from normal. Fracture of seventh and eighth ribs posteriorly. Diagnosis: Internal strangulation, possibly diaphragmatic hernia. Laparotomy. Strangulation of loop of gut in wound of diaphragm. Reposition by strong traction. Wound 3 cm. long. Heart and lung palpable. Closure of wound by four catgut sutures. Exact coaptation not possible. Recovery.[5]

CASE 10. Boy, 2½ years old, fell from second story on iron fence. Large abdominal wound with intestinal prolapse. Prolapse of stomach and intestine into left pleural cavity. Suture of large wound in diaphragm and stomach. Exitus after a few hours. Suture intact.[6]

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DO THE PARATHYROIDS FUNCTIONATE IN INTRAUTERINE LIFE?[1]

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CARLSON,[2] in examining the urine of a pancreatectomized pregnant dog, found that the post-operative rise of sugar was more delayed and the highest percentage less than in non-pregnant dogs. From this he theorized that probably the pancreas of the fœtus might furnish and transmit into the blood of the mother a quantity of internal secretion sufficient for a normal sugar metabolism. Subsequent experimentation proved the correctness of his deductions.

Influenced by his work, I reasoned that probably in parathyroidectomized pregnant dogs, tetany would be delayed till after delivery by a compensatory function of the fœtal parathyroids, and, in fact, that the symptoms usually associated with the removal of any organ of internal secretion might be delayed, or at least alleviated in pregnant dogs until post-partum.

In regard to the parathyroids this supposition, however, proved entirely fallacious, as my thyroparathyroidectomized dogs went into tetany earlier and died sooner than non-pregnant ones.

In looking over the literature, I found that somewhat similar work had been done, although not with the same object in view.

Halsted resected one thyroid lobe in a pregnant dog. The operation was followed by tetany, which subsided only with termination of pregnancy.

Verstraten and Vanderlinden performed partial thyroidectomy in a cat. Three years later the animal conceived and died in tetany.

Adler and Thaler[3] found that following partial thyroparathyroidectomy, tetany came on earlier and in a severer form in pregnant than in non-pregnant rats.

Caro,[4] in a great number of experiments, whereby he proves to his own satisfaction that tetany is due to resection of the thyroids and not the parathyroids, also used some pregnant dogs which I noticed died very soon after complete thyroparathyroidectomy.

His work, founded as it is upon a faulty knowledge of the dog thyroid, is, however, of very doubtful value, unless it could be used to prove just the opposite of his contention, which, I believe, it does.

A few cases in the human have been reported in which partial strumectomy (including of course, the parathyroids), was followed by tetanic convulsions in pregnancy, ceasing only with its termination.

The most interesting of these cases is the one reported by Meiner.[5]

This woman underwent a partial strumectomy in the fourth month of pregnancy, followed on the third day after the operation by tetany, which continued at irregular intervals during the remainder of the pregnancy, ceasing at once after delivery. A few years later, the patient again becoming pregnant, tetany reappeared, followed by abortion and again cessation of convulsions.

Reasoning as above, that the parathyroids of fœtal pups might work vicariously in parathyroidectomized mothers, I selected dogs in later stages of pregnancy, possibly within two or three weeks of term. Complete thyroparathyroidectomy was done in all of them, and in order to cause the least possible disturbance, very light ether anæsthesia was given and operation completed as rapidly as was consistent with thorough work.

DOG I

Was operated 12:30 P. M., October 17, 1911. The animal, after coming out of the anæsthesia, appeared in splendid condition the rest of the day.

October 18th, 8:00 A. M., we noticed slight tremor of the neck, muscles, and front legs. At 11:00 A. M., there was added a spastic condition of all the extremities, but no convulsions; pulse 140; resp. 44, very labored; temp. 101.2°. Abdominal palpation

[2] J. Am. Physiol., xxviii, Oct. 2, 1911.
[3] Ztschr. f. Geburtsh. u. Gynäk., 1908, 62, p. 194–223.
[4] Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1908, 17, p. 447–468.
[5] Archiv f. Gynäk., 1898, 55, p. 446.

[1] Read at the joint meeting of Chicago Medical Society and South Side Branch, May 15, 1912.

demonstrated fœtal movements. Vaginal examination was negative. 5:00 P. M. same.

October 19th, 8:00 A. M., no tremor; no spasm; less depression; the dog sits up. 5:00 P. M. same.

October 20th, 9:30 A. M., pulse 96; respiration 28; temperature 99.2°; apparently normal. 5:00 P. M., same.

October 21st, 8:00 A. M., dog found dead. Post-mortem gave evidence of beginning labor, otherwise negative. Weight of mother 8.5 kg. Weight of her thyroids 4.82 gr. Weight of pups 1.5 kg. Weight of pups' glands 1.6 gr.

DOG 2

Operation October 25, 1911, 12:16 P. M. 6:30 P. M., good condition with slight tremor of neck muscles.

October 26th, found dead. Post-mortem negative. Weight of mother 6.4 kg. Weight of her thyroids 4.82 gr. Weight of pups 0.73 kg. Weight of pups' glands 0.7 gr.

DOG 3

Operation October 27, 1911, 11:10 A. M. Thyroparathyroidectomy.

October 28th, 9:00 A. M., one pup born. At times slight tremor and rapid breathing; no spasm; pulse 120; temperature 101.2°; respiration 40. 5:00 P. M., some tremor, rapid respiration; second pup born. 10:00 P. M., dog in fair condition; one pup born between 5:00 and 10:00 P. M.

October 29th, 10:00 A. M., dog in good condition; slight tremors; another pup born. Mother takes the usual care of pup at birth.

October 30th, 10:00 A. M., tremor (general) spasms of front legs; pulse 140; respiration short, hurried, 52; temperature 101.6°; two pups born. 1:15 P. M., same.

October 31st, no tremor; no spasm; pulse 104; respiration 24; temperature 101.8°.

November 1st, 9:30 A. M., dog dying; killed; post-mortem negative. Weight of mother 9.2 kg. Weight of her thyroids 6.10 gr. Weight of pups 1.04 kg. Weight of pups' glands 0.58 gr.

DOG 4

November 2d, 3:00 P. M., thyroidectomy; thyroids enlarged and very vascular; apparently a small hæmatoma in one lobe.

November 3d, found dead; five pups living. Post-mortem decided hyperæmia of upper part of gut. Weight of mother 14.40 kg. Weight of her thyroids 7.0 gr. Weight of pups 1.04 kg. Weight of pups' glands 4.6 gr.

DOG 5

Thyroidectomy November 15th, 10:30 A. M., 5:00 P. M., in good condition.

November 16th, 10:00 A. M., tremor of all muscles; no spasms; pulse 120; temperature 101.2°. 5:00 P. M., characteristic tetany.

November 17th, 8:25 A. M., dog found dead. Post-mortem negative. Weight of mother 2.8 kg. Weight of her thyroids 2.6 gr. Weight of pups 0.47 kg. Weight of pups' glands 0.45 gr.

DOG 6

Thyroidectomy November 15, 1911, 11:00 A. M., 5:00 P. M., in good condition.

November 16th, 10:00 A. M., tetany (characteristic). Fluoroscopic examination was used in order to determine whether the fœtal pups were in tetany, but we were unable to assure ourselves as to whether or not. Temperate 101.8°. Dog died at about 12:00 M., was posted at once; six pups dead; temperature of one of these 102°; stomach somewhat contracted. Weight of mother 8.2 kg. Weight of her thyroids 4.15 gr.

DOG 7

P. Thyroidectomy November 18th, 10:30 A. M.

November 19th, 10:30 A. M., general tremor; dog lies down. 5:00 P. M., characteristic tetany.

November 20th, 10:00 A. M., tetany; severe, vaginal examination negative. 5:00 P. M., dog found dead; post-mortem negative. Weight of mother 7.6 kg.

DOG 8

Thyroparathyroidectomy February 15th, 10:00 A. M., 4:00 P. M., condition good. 8:00 P. M., tremor in neck muscles.

February 16th, 8:00 A. M., dog found dead; still warm; four pups dead. Post-mortem negative. Weight of mother 9.8 kg. Weight of her thyroids 7.7 gr. Weight of pups 5.70 gr. Weight of pups' glands 1.2 gr.

DOGS 9 AND 10

Died within twenty-four and forty-eight hours respectively. Records lost.

The results in this work were so uniform that I did not deem it necessary to use a greater number of animals.

The rapid demise of these dogs, however, made me at first think that probably there was something radically wrong with my technique; so in order to eliminate this factor, I asked Carlson, who is vastly my superior in this work, to operate some of the dogs. His two dogs, however, died within twenty-four hours.

The convulsions came on very early, but I did not observe, as did Adler and Thaler in rats, that the tetany was more severe than in non-pregnant dogs. The average post-operative life was about two days; five dogs died within twenty-four hours.[1]

In this laboratory, non-pregnant dogs

[1] It is specially interesting to note that dogs No. 3 and No. 9 lived longest (save No. 1), and also bore several pups before death

lived from five to ten days after thyro-parathyroidectomy. Why this difference in duration of post-operative life in pregnant and non-pregnant dogs? Clearly it lies in the condition of pregnancy; but why?

Is it due to a lessened body resistance incidental to the state of conception, or is the system overwhelmed by deleterious products from the fœtus and the placenta that would otherwise be neutralized by the parathyroids? The former is hardly likely as the animal then would probably depart from shock. Immediately following the operation, when entirely out of the anæsthesia, the animal may not show the least disturbance.

The latter supposition is more probable and is supported by the cases and experiments mentioned above, in which partial parathyroidectomy was followed by tetany.

In these cases, the parathyroids were able to control the situation under ordinary conditions, but when the state of pregnancy was added, there was a relative hypofunction; the gland not being able to take care of the added products from the fœtus.

This makes me doubt whether the particular glands in question functionate at all in intrauterine life. Probably these, and also some other organs, as the lung, are thrown in action only simultaneously with extrauterine existence.

Should these glands functionate as they do later in life, then there would be no extra material thrown on the parathyroidectomized mother, as each gland would take care of its own pup, and consequently life should not be very much more shortened than in non-pregnant dogs, unless, of course, the whole secret lies in the placenta.

Halsted has shown that thyroid of fœtal pups in a partially thyroidectomized mother underwent hypertrophy, supposedly of a compensatory nature. If his experiments were done on mothers with hyperplastic glands, then they are not at all conclusive, as in two mothers with enlarged thyroids of above series, I found all the pups with greatly enlarged glands.

This thyroid enlargement in fœtal pups of goitrous mothers thus furnishes a direct evidence of the hereditary origin of strumæ, at least in early life in some of the canines.

That such compensatory function as described by Halsted does not take place in the parathyroids is very likely, because if it did, then death would not come sooner, but would be at least deferred in pregnant dogs.

It would be of great importance if one could ascertain whether the fœtal pups also go in convulsions with the parathyroidectomized mother.

Tetany of the fœtus would favor the supposition that the parathyroids were inactive at this early period, but not entirely prove it, as the fœtus might be completely overpowered by substances from the maternal blood. Lack of convulsions might possibly mean glandular activity. Carlson and I used the fluoroscope as above, but were unable to make out whether pups were in spasms or not. Probably it could be done in smaller animals. Whether the parathyroids are active at once after birth, or, if not, at what period, could, of course, be demonstrated by thyroparathyroidectomy of pups at different ages.

I have, so far, done only one a week old. It was found dead in forty-eight hours. No convulsions were seen, but it may have had only one. Other glands should be used for this work, especially the suprarenal one. As I have used only one dog for this work (in a poorly done operation), I can give no opinion. The animal used, however, died sooner than most of those non-pregnant ones on which the same operation has been practiced in the laboratory.

There is no doubt but that the removal in pregnant animals of any organ or sets of organs of an internal secreting or eliminating function would hasten, and possibly intensify the symptoms ordinarily associated with such removal, unless, of course, compensated for by vicarious organic function in the fœtal pups. (Such compensating function would, of course, be of no avail when it concerns organs of elimination.)

The post-operative life of pregnant thyro-parathyroidectomized dogs should, it seems to me, bear some relation to the stage of conception.

The earlier in pregnancy, the longer death should be delayed, as then a less amount of extra products would be thrown on the mother than later in pregnancy, when the animal, as is seen from above, may become rapidly overpowered by an excess of non-neutralized substances, of the nature of which we know absolutely nothing, and the presence of which we surmise only by their powerful and destructive symptomatic manifestations.

The results in this work may, in a measure, support the parathyroid theory of eclampsia without by any means proving it. It was interesting to note that in the pups of this series, the left gland was almost invariably the larger and heavier, exactly the opposite from the condition in the adult.[1] The relation between glandular and body weight in the pups of mothers with enlarged thyroids was as low as 1–130, whereas in other pups from non-goitrous mothers, from 1–1000 to 1–2000.

The relation between the body weight of the mother and that of her glands averaged 1–1180 and in the pups 1–1049. Thus the glands of the pups were relatively slightly larger. The relation between the weight of the glands of the mother and of those of the pups averaged 1–8.

Careful microscopic examination is being made of each gland, but as the work is not yet completed, it will be reported in a subsequent paper.

[1] Werelius, J. Am. M. Ass., lxii, p. 449.
Werelius, Surg., Gynec. & Obst., Aug., 1910, p. 152.

CONCLUSIONS

1. Thyroparathyroidectomized pregnant dogs (in later stages) seemingly go in convulsions earlier and die sooner than non-pregnant dogs.
2. In thyroparathyroidectomized pregnant dogs, fœtal parathyroids probably do not then compensate for the mothers' glands.
3. Possibly some glands of internal secretion do not functionate in intrauterine life.
4. Undoubtedly, the earlier in pregnancy thyroparathyroidectomy is performed, the longer the post-operative life.
5. The results in this work may in a sense support the parathyroid theory in eclampsia.
6. Direct evidence of heredity as an etiologic factor in goiter is shown in this series.
7. In fœtal pups, left thyroid gland is almost always the larger.

THE INFLUENCE OF MYOMATA ON THE BLOOD SUPPLY OF THE UTERUS, WITH SPECIAL REFERENCE TO ABNORMAL UTERINE BLEEDING[1]

Based on the Study of 150 Injected Uteri Containing These Tumors

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THE purpose of the present article is to show the blood supply of uteri containing myomata, with reference to the changes caused in it by these tumors, and especially those which would lead to abnormal bleeding, as found in the clinico-pathological study of 150 injected uteri containing myomata.

At the last meeting of the American Gynecological Society, held at Atlantic City, May 24, 1911, I presented a paper entitled "The Blood Supply of Uterine Myomata (Based on the Study of 80 Injected Uteri Containing These Tumors)." This paper, which included a study of twenty more injected specimens, was presented before the second annual session of the Clinical Congress of Surgeons of North America on November 15, 1911, and appeared in the *Transactions* of the American Gynecological Society for 1911, and in Surgery, Gynecology and Obstetrics, March, 1912.

[1] Read before the American Gynecological Society, May 28, 1912.

The present study is a continuation of the previous one, and is of greater clinical value, because the changes in the circulation of the uterus caused by these tumors contribute more to their symptomatology and interfere more with the health of the individual than the blood supply of the tumors themselves.

The literature of this subject, based on the study of injected specimens, is meager and has already been referred to in the previous paper.

The material for the present study consisted of the 100 injected uteri containing one or more of these tumors which were used in the preparation of the previous paper, and 50 additional ones, all of which were removed at operation and injected soon afterwards.

The injection mass used was 15 per cent gelatin which contained in suspension either a pigment or some material (usually bismuth subcarbonate) which was impervious to the X-ray. In 52 specimens, either the arteries or veins, or both, were injected with a pigment (if both were injected, Venetian red was used for the arteries and ultramarine blue for the veins). In the remaining 98 specimens, one vascular system was injected with a mass impervious to the X-ray, and the other system was usually injected with a colored mass. Stereoscopic radiographs of the specimens injected with the mass impervious to the X-ray were found to be of great value in the study of the various phases of this subject.

The material for this study may be grouped according to the clinical diagnoses made before the operation, as follows: Myomata, 79; pelvic inflammatory conditions, 20; uterine bleeding of obscure origin, 16; ovarian cysts, 12; carcinoma of the cervix, 8; carcinoma of the body, 5; descensus and retrodisplacements of uterus, 5; ectopic pregnancy, 3; hydatiform mole, 1; sarcoma, 1. This shows how frequently myomata are encountered when operating for other conditions; i.e., over forty-seven per cent of the material was obtained at operations which were undertaken for other conditions than myomata.

THE BLOOD SUPPLY OF THE NORMAL UTERUS

The course of each uterine artery along the side of the uterus and its free anastomosis with the ovarian artery of the same side are well known (Fig. 1). From each uterine artery branches arise, at intervals, which penetrate the uterus; each one either divides into two branches, one supplying the anterior and the other the posterior uterine wall, or without dividing it supplies either one or the other uterine wall. At the level of the internal os their course within the uterus is at right angles to the long axis of that organ; below this level it is inclined downward, while above it is directed obliquely upward and the arteries themselves are larger. Frequently one intramural artery is much larger than the rest and appears as a terminal branch of the main uterine artery. This is known as the fundal branch. These arteries present many minor variations, but the general plan of their origin and course is the same. These main intramural arteries which I have called "arcuate" lie between the outer and middle third of the uterine wall, and each one supplies a quadrantal segment of the uterus corresponding to a segment of either the anterior or posterior half of the Müllerian duct of that side (Fig. 2). They terminate in median peripheral and radial (centripetal) branches. The peripheral terminal branches of some of the arcuate arteries of one side anastomose freely with similar branches of arcuate arteries of the opposite side, thus establishing a free communication between the two main uterine arteries. Along the course of each arcuate artery, *radial* (centripetal) and *peripheral* (centrifugal) branches arise. The radial branches are the larger and more numerous. They supply the myometrium, mesial to the arcuate artery from which they arise, and *terminate in the endometrium*. The peripheral arteries nourish the peripheral portion of the myometrium. There is a free anastomosis of the arterioles of the peripheral branches of neighboring arcuate arteries of the same side, and also of the arterioles of the radial branches near their origin from the arcuate artery, but the distal portion of the radial arteries are apparently end arteries.

The arterial system of the uterus enables us to divide the uterine wall into three zones: first, the peripheral (the outer third), which is nourished by the peripheral arteries; second,

the arcuate, the narrow zone in which the arcuate vessels lie; and, third, the radial (the inner two thirds), which is nourished by the radial arteries.

In order to distinguish the arteries from the veins, an injection mass of sufficient coarseness was used so that it usually did not escape through the arterial capillaries into the veins, and as a result I may have failed to inject some of the finer capillaries of the endometrium. The fine terminal branches of the radial arteries penetrate the base of the endometrium, and arterial capillaries were found to extend only a short distance in the uterine mucosa. On the other hand, the veins of the endometrium (the venous capillaries) are easily injected through the uterine and ovarian veins. Occasionally the arterial injection mass escaped from the terminal branches of the radial arteries into the venous plexus of the endometrium, and these specimens presented a very confusing picture, as the arteries and veins contained the same mass; and even if the arterial mass was followed by a venous one of another color the arterial mass remained in the veins of the endometrium.

The arrangement of the venous system of the uterus is as follows (Fig. 3): First, a rich plexus in the endometrium, which is fed by the terminal branches of the radial arteries to which reference has been made; second, a similar but larger plexus of the myometrium, which communicates with that of the endometrium by venous channels. There is often a narrow zone of the myometrium about the endometrium which is relatively anæmic (under normal conditions), and through which the venous channels pass, uniting the two plexuses. This "protection" zone is possibly an important means of regulating physiological as well as pathological uterine bleeding, as will be considered later. About the periphery of the myometrium, especially on the sides, and sometimes accompanying the arcuate arteries, are collecting veins which convey the venous blood of the uterus to the uterine veins situated between the layers of the broad ligament. Since the entire venous system of the uterus is easily injected through the uterine and ovarian veins, the intrinsic uterine veins do not contain valves.

The study of the uterine circulation from the injected specimens, bearing in mind that there are not any valves in the veins and that the uterus is a muscular organ which may relax and contract, suggests that the relaxations and contractions of the uterus may be of great importance in aiding its circulation; i. e., the *uterus is essentially a "pelvic heart"* (Theilhaber). This "cardiac" function is seen during pregnancy and menstruation and possibly may occur during the quiescent non-pregnant condition, although I have not been able to obtain any definite proof of the latter. When relaxed the plexuses of the endometrium and myometrium would be filled with venous blood and the arterial blood would easily gain access to the endometrium, and in contracting, this blood would be forced out of the uterus into the pelvic veins. My studies support the views of Theilhaber in regard to the importance of the muscular efficiency of the uterus in aiding the uterine circulation and in regulating uterine bleeding.

During pregnancy, the uterine arteries increase in size, and the arcuate arteries whose radial branches nourish the placenta become hypertrophied. The venous plexus of the myometrium is distended with blood when the uterus is relaxed. On account of the increased vascularity of the organ as a whole, the demand for its "cardiac" function is greater than in the non-pregnant condition, and it is in pregnancy that the intermittent contractions are most noticeable. After labor the process of involution occurs, and Goodall [1] believes that the uterus renews all of its arteries, the renewal consisting in the building of a new vessel within the lumen of the old one.

Adler and Hitschmann have divided the menstrual cycle into four periods: the post-menstrual, interval, premenstrual and menstrual. At the post-menstrual period they describe the endometrium as thin, anæmic and smooth. It gradually increases in thickness as the individual approaches menstruation, and at the premenstrual period it is thicker and more vascular than at any other time. By the process of menstruation the endo-

[1] Am. J. Obst., N. Y., lx, 1909, 921-985.

metrium assumes the post-menstrual condition.

It would also seem that the entire uterus contained more blood in the premenstrual period, and that menstruation may be looked upon as a form of labor, followed by a process of involution differing in degree from post-partum involution.

I have studied all my specimens with a knowledge of the age of the patient, and the date of the last menstruation if operated upon before the menopause, and have injected several specimens from patients who were menstruating at the time of the operation. I have found that the endometrium differs so much in its thickness and vascularity in individual cases that it is impossible to determine the exact stage of the menstrual cycle from the appearance of the endometrium except during the actual flow. I have seen the endometrium thick and very vascular within a week after the menstrual period, and relatively thin in the premenstrual period. It must be borne in mind that the degree of congestion during life cannot be determined from the injected specimen; nevertheless my work in a general way confirms the descriptions of Adler and Hitschmann as to the changes of the endometrium in the various phases of the menstrual cycle. As a woman approaches the menopause the uterus becomes less vascular, both arterial and venous, the endometrium and uterine wall become thinner, and the proportion of the muscle to connective tissue changes in the wall, the connective tissue predominating. I believe that injected uteri can only be intelligently studied when both the age of the patient is known and the date of the last menstrual period, irrespective of the pathological condition present.

THE FACTORS REGULATING MENSTRUATION

In the present communication we are specially concerned with the vascular changes in the uterus leading up to and associated with menstruation. What causes the onset of the flow? Why does it continue for a certain number of days? Why does it stop? Why irregular or regular, scanty or profuse, of short or of long duration?

OVARIAN FUNCTION AS A FACTOR IN REGULATING MENSTRUATION

We know that ovarian activity or function is responsible for the menstrual cycle. If the ovaries have been entirely removed, the changes in the uterus leading to menstruation do not take place, and physiological uterine bleeding will not occur.

On the other hand, ovarian activity may normally exist, and yet the individual may not menstruate, as shown by women becoming pregnant before puberty, during the amenorrhœa incident to lactation, after the apparent menopause, and in those with suppression or absence of menstruation due to other causes. A non-pregnant woman then, with apparently normal ovarian function *as far as ovulation is concerned*, may not menstruate. If she does not, its non-appearance is due to some condition within the uterus, or even outside. I have long been impressed with the fact that patients with abnormal menstruation, either irregular, scanty, profuse, or prolonged, may have ovaries which anatomically and histologically appear normal. We also find extensive pathological condition of the ovaries, especially large cysts, in patients with normal menstruation. We must conclude that the influence of the ovaries on menstruation, both as regards its periodicity, the duration of the flow, and the amount of blood lost, whether scanty or profuse, is not so much dependent upon the anatomical structure of the ovaries, which we are able to detect, as upon their functional activity and the interrelation between this and the uterus, and the influence of other factors which we have not yet definitely determined. Here again, as will be shown, the functional activity of the uterus plays an important part in regulating the amount of blood lost, and the latter is not dependent entirely upon anatomical changes which we can detect.

THE ENDOMETRIUM

The menstrual flow occurs as an escape of blood from the endometrium into the uterine cavity. A study of the injected specimens shows us that the distal portion of the radial arteries terminate in the endometrium, and that these branches are very small, and the

capillaries supplying the uterine mucosa are very difficult to inject with the material I have used (Fig. 2). On the other hand there is a rich venous plexus in the endometrium, whose blood is carried by venous channels to the venous plexus of the myometrium (Fig. 3). If a uterus, removed from a patient who was menstruating at the time of the operation, was injected; the arterial injection mass did not escape into the uterine cavity *but the venous injection mass always did*. This we would expect from the study of injected uteri removed in the intermenstrual period. From my studies I would infer that *the normal menstrual flow is entirely a venous hæmorrhage from the venous plexus of the endometrium, and it is only possible when there are changes in this plexus which will permit the blood to escape.* I offer as proof of the latter statement that I have never seen the injection mass escape into the uterine cavity unless the patient was flowing (either physiologically or pathologically) at the time of the operation, or else just before or after such a flow. The venous plexus is very strong during the intermenstrual period, for I have often purposely used great force, and yet the injection mass did not escape into the uterine cavity. When the injection mass escaped, it occurred either in the form of oozing from the portion of the venous plexus just beneath the endometrial epithelium, or a "hæmatoma" of the mass formed in the endometrium, with subsequent rupture of the portion of the mucosa over it, permitting its escape into the uterine cavity (Figs. 4 and 5).

Adler and Hitschmann state that the endometrium is thicker just before menstruation than at any other time, and that this thickness is due to actual hypertrophy, with marked glandular hypertrophy and increased vascularity. As changes in its venous plexus are necessary for the escape of the blood and as there is often a marked glandular hypertrophy at this time, suggesting an increased glandular activity, the views expressed by Frankl[1] that menstruation is a biochemical process dependent upon a ferment produced by these glands, which ferment alters the venous plexus or portions of it, thus permitting an escape of blood, seems possible. It would be expected that the thicker and the more vascular the endometrium, the greater the flow, but this does not necessarily follow. I have seen specimens removed during the interval and premenstrual period with a very thick and vascular endometrium, and yet the patient gave a history of a moderate menstrual flow; and other specimens removed under similar conditions showed a much thinner endometrium, and yet menstruation was very profuse. The type of menstruation is not entirely dependent upon the character of the endometrium; here again functional activity plays an important part and the degree of this activity cannot always be detected from the anatomical structure.

It is generally considered that under normal conditions the menstrual blood will not clot. In other words, the endometrium receives coagulable blood and it escapes in a non-coagulable state. The endometrium is supposed to secrete some substance which inhibits clotting. Sturmdoff believes that this is an important local hæmatological factor in the causation of uterine bleeding. The discussion of this phase of the subject and references to the literature may be found in his article.[2] I obtained careful menstrual histories in regard to clotting from 100 women who either were not suffering from any pelvic disorder at the time, or the history applied to the character of their menstruation previous to their pelvic trouble. Sixty-five gave a history of no clotting; the flow was scanty in 15, moderate in 44, and profuse in 6. Thirty-five gave a history of clotting; the flow was scanty in 2, moderate in 8, and profuse in 25. Of the 100 cases, the menstruation was scanty in 17 (no clotting in 15, and clotting in 2), moderate in 52 (no clotting in 44, and clotting in 8), and profuse in 31 (no clotting in 6, and clotting in 25). It would seem that patients with a scanty or moderate flow were not likely to have clots (59 out of 69), while those with a profuse flow were likely to (25 out of 31). This is in accord with the findings in the injected specimens; if the flow is profuse the endometrium does not have an opportunity to act upon it and much of

[1] Archiv. f. Gynäk., 1911, xcv, 269–313.

[2] N. Y. S. J. Med., 1911, ii, 1161-64.

it is probably a reflux (no valves in the veins) from the rich plexus of the myometrium. While the action of the endometrium on the blood (inhibiting its power to clot) may be an important factor in the onset of the flow, it would seem to me that it may have but very little influence in the causation of profuse menstruation.

THE MYOMETRIUM AS A FACTOR IN THE CONTROL OF MENSTRUATION

In considering this we must also include its blood-vessels, and especially the rich venous plexus into which the endometrial venous plexus empties. We are all aware of the fact that contraction of the uterus will cause endometrial hæmorrhage to cease, and relaxation of the same will make it more profuse. We have the opportunity to observe this not only postpartum, but also when curetting the uterus, especially for an incomplete abortion — the uterus will often dilate, leading to a profuse hæmorrhage, and the contraction of the uterus will cause the bleeding to cease.

Following curettement of the uterus, the bleeding soon ceases. The question naturally presents itself, Why is not the usual curettage for sterility, etc., followed by prolonged bleeding simulating the menstrual flow? The endometrium and its blood-vessels have been injured. I have injected only one uterus in which there had been a curettage as the first step in the operation. In this specimen both the arterial and venous injection masses escaped into the uterine cavity, showing that both the arteries and veins of the endometrium, and also possibly some of those of the myometrium, had been injured; yet had the uterus not been removed the bleeding would soon have ceased. A study of injected specimens will convince one that contractions of the uterus would easily compress not only the venous channels leading from the endometrium, but also the distal branches of the radial arteries, which supply the endometrium and are very small. The latter, after being severed, may also retract within the musculature, due to their elasticity, and soon cease to bleed. Contraction of the uterus would also compress the endometrium and make smaller the uterine cavity. The myometrium is apparently an important factor in the control of physiological uterine bleeding.

We have discussed the influence of ovarian activity on the menstrual cycle as manifested in the changes occurring in the endometrium. The study of this phase of the subject is relatively easy, but the study of the changes occurring in the myometrium is more difficult. It is supposed that the uterus contains more blood just prior to the menstrual flow, i. e., it is "congested." I have endeavored to prove this, but there is so much individual variation in the specimens removed that I have been unable to tell, by the appearance of an injected myometrium, at what stage in the menstrual cycle the uterus was removed, just as I have been unable always to determine by the appearance of the endometrium (except during the actual flow) what stage of the menstrual cycle it presents. Nevertheless my studies have led me to believe the venous plexus of the myometrium is capable of containing more blood just before the menstrual flow than at any time, and possibly more blood may be carried by the arteries to the uterus. The greater the relaxation of the uterus, the more blood it will contain. We would naturally suppose that the greater "the uterine congestion" the greater the menstrual flow, but this is not invariably true. The plexus of the myometrium may be greatly dilated, and yet the flow is not necessarily profuse, as may be seen in some of the uteri containing intramural myomata, which are not necessarily associated with profuse menstruation. *It is not the amount of blood* within the uterus or pelvic veins which determines the amount of blood lost at the menstrual flow *as much as the control of this blood*, i. e., the ability of the uterus to hold back the venous blood. A great factor in preventing the escape of this blood into the uterine cavity is the tonicity of the uterus. It would seem that during relaxation of the uterus at the menstrual period the venous blood escapes into the uterine cavity, and during contraction of the uterus the flow is retarded by occlusion of the cavity and compression of both arteries and veins, but the blood which has escaped into the uterine cav-

ity is forced out through the cervix. If the endometrium is intact, bleeding will not occur during relaxation of the myometrium. This may be observed during pregnancy, when the uterus is frequently relaxed, and I have observed it during curettage; the dilatation of the cervix may cause uterine relaxation, as shown by the length of the uterine cavity, and yet bleeding does not occur until the endometrium is injured.

My studies have led me to believe that the myometrium is a very important factor in the regulation of the menstrual flow. It may receive stimuli from many outside sources, the most important of which is probably the ovary.

As women grow older all the pelvic generative organs become less vascular and less active. The arterial system of the uterus becomes physiologically sclerotic, the venous plexuses atrophy, the endometrium becomes thinner and anæmic, the muscles of the myometrium atrophy, and the proportion of fibrous tissue increases and the entire organ becomes smaller. Under normal conditions menstruation becomes gradually less and finally ceases. Under abnormal conditions of uterine inefficiency, and here I believe, with Theilhaber, that the most important single factor is muscular insufficiency, menstruation may become prolonged and more profuse, and there may be irregular or intermenstrual bleeding.

SUMMARY

As a result of ovarian activity the uterus of the sexually active woman becomes periodically hyperæmic, the height of hyperæmia (congestion) occurring in the premenstrual period. The endometrium undergoes *functional active changes*, often manifesting themselves by hypertrophy, especially glandular, hyperæmia, and œdema. The onset of menstruation is established by changes in the venous plexus of the endometrium, permitting the blood to escape into the uterine cavity. The continuation of the flow is probably made possible by several factors; such as ovarian activity, the continuation of the uterine conditions which established it, and the time necessary for the regressive changes to occur and repair to take place. Menstruation then is associated with and followed by a process which may be called involution.

The amount of blood lost is determined by many factors and their interrelation, such as ovarian activity, the anatomical and functional changes in the endometrium and myometrium, and influences other than ovarian outside the uterus. Of all these factors, I believe that the muscular efficiency of the uterine wall must play an important part, for this is the only means of closing the uterine cavity and of controlling the venous channels which unite the plexus of the endometrium with that of the myometrium, and also the arterial blood conveyed to the mucosa. The "protective zone" (anæmic) through which the terminal portion of the radial arteries and the venous channels pass would be the portion of the uterus most readily compressed by uterine contraction.

THE CLASSIFICATION OF UTERINE MYOMATA

Myomata may arise in the body of the uterus, the usual situation, or in the cervix. They may be grouped topographically into the *intramural*, the *subserous* (including *intraligamentary* and *retroperitoneal*), and the *submucous* (the usual classification). We may also group them, according to the source of their main arterial supply, into *peripheral* and *radial*. A *peripheral* myoma is one arising in the peripheral zone of the uterus and receiving its chief or sole arterial supply from a peripheral branch of an arcuate artery. All peripheral tumors are either intramural, subserous, intraligamentary, or retroperitoneal. A *radial* myoma arises in the radial zone and receives its chief or sole arterial supply from a radial branch or branches of an arcuate artery. All radial tumors are primarily intramural. They may persist as such, or eventually become subserous or submucous. When they do so they carry their nutrient artery or arteries with them.

These tumors may also differ morphologically. A myoma may be simple, that is uninodular, or compound. In the latter case it may be referred to as conglomerate or multinodular. It may be discrete, with sharply defined limits, or diffuse, merging

gradually into the surrounding tissues. We must also consider a somewhat unusual form, the adenomyoma, in which areas of uterine mucosa are found.

In studying the influence of myomata on the circulation of the uterus, we must consider in each case the variety of myoma or myomata present, their blood supply, the age of the patient, and if before the menopause at what stage of the menstrual cycle the uterus was removed. It is often difficult to study the influence of each variety on the blood supply of the uterus, because usually several myomata are present in each specimen, and often representing several varieties.

In the 150 uteri containing myomata, multiple tumors were found in 144. The following classification of this material may be made:

Small peripheral myomata projecting from the surface of the uterus, which may be designated as subserous, were encountered in 83 specimens. In only one specimen was only one myoma found, in all the others intramural tumors were also present.

Large pedunculated myomata 10 cm. in diameter (the largest being 22 cm.) were encountered in only three specimens, and these were all associated with intramural myomata.

Small intramural myomata, either peripheral or radial, were found in 146 of the uteri removed, and in only two instances was only one tumor present.

Medium size (2.5 cm. or over) and large intramural myomata were found in 76 specimens, and in three only was a single tumor present.

Submucous myomata (i. e., over half the circumference of the tumor projecting into the uterine cavity) were found in 16, and all were associated with other varieties of myomata.

Adenomyomata were found in 12, and all were associated with other varieties.

Only one definite cervical myoma was found, but two others were encountered while I was collecting this material; but were not injected, as the tumors were removed without removing the uterus.

THE BLOOD SUPPLY OF UTERINE MYOMATA

All myomata, except some of the very small ones, have an arterial blood supply which can be easily seen with the naked eye. As they increase in size they become more vascular (arterial), so that the medium size and large ones contain more vessels filled with the arterial injection mass than the myometrium. The vessels filled with the venous injection mass are usually few in numbers and in some specimens, even large tumors, I have been unable to demonstrate any "veins" in the substance of the tumor. This is in marked contrast to the myometrium, where the venous supply predominates over the arterial.

The arterial blood is carried to these tumors by means of nutrient arteries which are either peripheral or radial branches of an arcuate artery, hence myomata may be grouped as either peripheral or radial. In many only one nutrient artery is found; in others two or three, with one predominating. The branches of the nutrient artery extend over the surface of the tumor and penetrate its substance, thus supplying the intrinsic "arteries" of the tumor, which I have stated are often much more abundant than those in the myometrium and differ in their arrangement, etc. (See previous article on the blood supply of uterine myomata.) Often the only communication found between the arteries of the tumor and those of the myometrium is by the nutrient arteries. In some of the medium size and large tumors, in addition to the nutrient arteries, an anastomosis was found between the arterioles of the myometrium about the tumor and similar vessels in the periphery of the myoma. When the tumors change their position their nutrient artery accompanies them. In many of the medium size and larger myomata the development of their intrinsic arteries is so great that the injected specimen appears as an arterial angioma rather than a myoma.

The myomata, as already stated, are usually poorly supplied with veins in their substance, and in some specimens I have not been able to demonstrate any. I have proven in some, that the arterial blood gains access to veins in the substance of the tumor, i. e., where the latter are present; but where veins

cannot be demonstrated we must assume that this occurs about the periphery of the tumor, or else the arterial blood leaves the tumor as such and gains access to veins in the surrounding myometrium. The enormous number of arteries in the tumor and their tortuous course, together with the apparent inefficient venous outlet, suggest that the circulation of the blood within the tumor is sluggish. For further description of the blood supply of these tumors, see previous article on the subject. On account of the great vascularity of many of these tumors, we must look for other changes in the circulation of the uterus than those caused by the mechanical influence of the tumor or tumors.

SMALL SUBSEROUS MYOMATA

Changes Caused by Them in the Circulation of the Uterus

I have included in this group all myomata under 2.5 cm. in diameter projecting from the surface of the uterus for over one half their circumference, and that covered only by peritoneum. As stated, this variety was found in 83 specimens, and in only one specimen was but one myoma present. In all the others intramural myomata were found. A study of the injected specimens shows that the branches of the nutrient artery of the tumor spread over the surface of the tumor from its base, and thence penetrate the substance of the tumor. The tumors of this size, while containing intrinsic arteries, are usually less vascular than the myometrium. Veins are found over the surface of the myoma, but it is usually impossible to demonstrate any within its substance. Aside from a slight increase in size of the peripheral artery from which the nutrient artery arises there is not any apparent change in the arteries of the uterus, and the same is true of the veins. The study of the injected specimens supports the clinical findings in these cases, i. e., small subserous myomata do not disturb the circulation of the uterus and do not alter menstruation. The same was found to be true of the medium size subserous myomata (2.5 to 10 cm. in diameter), of which 11 were studied.

LARGE SUBSEROUS MYOMATA (OVER 10 CM. IN DIAMETER)

Changes Caused by Them in the Circulation of the Uterus

Only three such specimens were present in this series: one was associated with several intramural myomata, small and large, and a submucous myoma, and therefore was not adapted to the study of this phase of the subject. The other two also contained several intramural and subserous myomata, but fortunately they were of small size. In one of these two the subserous tumor was 10 cm. in diameter, very vascular, and derived its chief blood supply from one uterine artery (Fig. 9). This artery was enlarged, and it could be seen in the radiograph that the excess blood supply over the normal was diverted from the uterus to the tumor. The body of the uterus was not enlarged, the arterial supply was not increased, but rather appeared less than normal, suggesting that the tumor might receive more than its share of arterial blood. Large veins were present in the pedicle of the tumor, and the venous blood was carried from the tumor by means of large venous channels in the peripheral zone of the uterus (Fig. 10). From a study of the specimen one would suppose that the tumor would not influence menstruation, and such was the history of the case — menstruation regular, normal, and moderate. The second specimen was larger, the tumor, measuring 22 cm. in diameter, arose from the middle of the posterior wall of the uterus, and was therefore nourished by both uterine arteries. Both uterine arteries were greatly enlarged, and what has been said about the previous specimen can also be said about this one (Figs. 7 and 8). Menstruation in this patient had always been profuse but had not increased in amount or duration. These two cases show that while these tumors alter the arteries from which their nutrient arteries arise, and give rise to large venous channels in the pedicle of the tumor and in the peripheral zone of the uterus, the radial zone is unaffected, and we would expect that menstruation would usually not be altered; and such has been our clinical experience.

Fig. 1. Radiograph of the arterial supply of the entire uterus. X 1. Nullipara, aged 25; arteries injected with bismuth subcarbonate; autopsy specimen. The course of each uterine artery is shown along the side of the uterus, and from these the intrinsic uterine (arcuate) arteries arise.

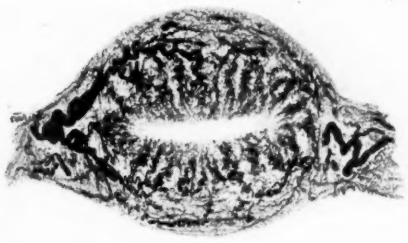


Fig. 2. Arterial supply of the uterine tissues. X 1. Radiograph of a cross slice, 3 mm. thick, of the body of the uterus. Nullipara, aged 34; arteries injected with bismuth; uterus removed for chronic pelvic peritonitis. The arcuate arteries, the large arteries and a small portion of a third, two of which appear in the illustration, pass between the outer third and inner two thirds of the uterine wall and terminate, in the median line, in radial and peripheral branches. They divide the uterine wall into two zones —the outer or *peripheral* zone, which is nourished by peripheral branches of the arcuate arteries, and the inner or *radial* zone, which is nourished by radial branches, the latter terminating in the endometrium by fine capillaries. Each arcuate artery, with its peripheral and radial branches, supplies a quadrantal segment of the uterus corresponding to the anterior or posterior half of the Müllerian duct of that side. When the uterus is relaxed arterial blood would easily gain access to the endometrium, but when contracted it would seem that the terminal arterioles and capillaries of the radial arteries would be easily compressed.

Some of the large venous channels in the pedicle of the tumor are very superficial, and similar channels are found about the base of the tumor. One can readily see that these might easily be injured by movements of the tumor and give rise to bleeding into the peritoneal cavity. Such a complication occurred in this series, the injury arising from a bimanual examination of the patient made before the operation.

SMALL INTRAMURAL MYOMATA (UNDER 2.5 CM. IN DIAMETER)

Changes Caused by Them in the Circulation of the Uterus

As has been stated under the classification of uterine myomata, these were found in 146 of the 150 specimens, and only in two instances was only one tumor present. They were present in all but three specimens where medium size and large intramural myomata were found, in all specimens containing submucous myomata, adenomyomata, and medium size and large subserous myomata. This group alone was found in uteri which were removed for the following conditions: pelvic inflammation, 14, including two cases of puerperal infection with portions of retained placenta; uterine bleeding, 16; ovarian cysts, 7; carcinoma of the cervix, 7; carcinoma of the body, 5; retrodisplacements and prolapse, 5 (uterus removed on account of myomata discovered at operation); ectopic pregnancy, 3; sarcoma and hydatiform mole, each, one. These tumors develop either in the peripheral or radial zone of the uterus, and are either peripheral or radial tumors. I have not counted all the tumors found in the 146 specimens, and so cannot state in which zone they occur most frequently, but apparently in the radial zone; and this would be expected, as it is much the larger zone. All

Fig. 3. Venous supply of the uterine tissues. X 1. Radiograph of a cross slice of the body of the uterus as shown in Fig. 2. Nullipara, aged 30; veins injected with bismuth through the uterine and ovarian veins. Uterus removed for chronic pelvic peritonitis during the interval stage of the menstrual cycle. There is a rich venous plexus of the endometrium, and also of the myometrium, which communicate with each other by channels which pass through a relatively anæmic zone. Collecting veins are present about the periphery of the myometrium, especially at the sides (and, at times, accompanying the arcuate arteries), which convey the venous blood to the uterine and ovarian veins. Valves are not present, and therefore when the uterus is relaxed the venous blood in the myometrium could easily be forced back into the plexus of the endometrium, and if the latter was injured (physiologically or otherwise) it would escape into the uterine cavity. Contraction of the uterus would make the uterine cavity smaller, compress the endometrium, and force the venous blood of the latter into the myometrium, and thus prevent bleeding into the uterine cavity. This is in accord with clinical observations.

Fig. 4. Venous supply of the uterine tissues. Close of menstruation. X 1. Radiograph of a cross slice of the body of the uterus, as in Fig. 3. Nullipara, aged 31; veins injected with bismuth. Uterus removed, at the close of menstruation, for chronic pelvic peritonitis with bilateral ovarian cysts. The injection mass does not escape into the uterine cavity except during the menstrual flow or just before or just afterwards—showing that changes in the walls of vessels of the endometirum are essential for the flow. I have never been able to force the arterial mass into the uterine cavity at this time, but always the venous, and never the latter except at the above mentioned times. This demonstrates that the menstrual flow is mainly, if not entirely venous. We would expect this from the study of our specimens. Compare Figs. 2 and 3.

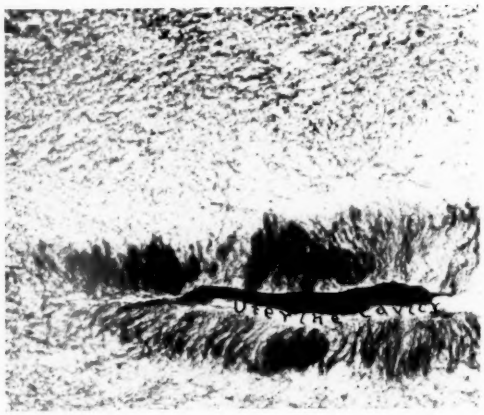


Fig. 5. Venous supply of the endometrium. Close of menstruation. X 4. Enlargement (X 4) of a portion of the radiograph shown in Fig. 4. The menstrual flow arises from the venous plexus of the endometrium and escapes either into the tissues of the latter, forming a hæmatoma, and thence into the uterine cavity, or it escapes directly into the cavity from the superficial portion of the endometrial venous plexus. See black mass in uterine cavity. As stated, changes in this plexus are essential for the menstrual flow. Contraction of the uterus would compress the endometrium and the terminal branches of the radial arteries (see Fig. 2), and also force the venous blood out of the uterus, and therefore lessen the flow. Relaxation of the uterus would permit the arterial blood to more readily reach the venous plexus of the endometrium, and, as there are not any valves in the veins, the venous blood of the myometrium could be easily forced back into the endometrium, and therefore make the flow more profuse.

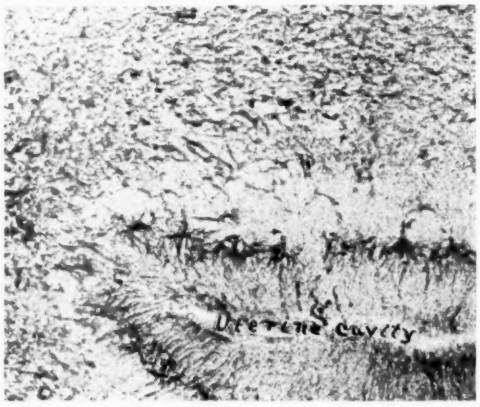


Fig. 6. Venous supply of the endometrium. Interval stage of the menstrual cycle. X 4. Enlargement (X 4) of a portion of the radiograph shown in Fig. 3, to be compared with Fig. 5, showing menstruating endometrium.

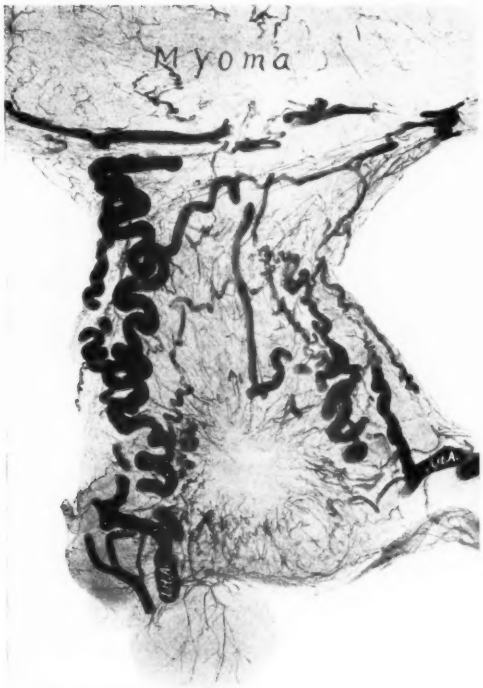


Fig. 7. Subserous myomata, changes in the arterial circulation of the uterus. Slightly reduced in size. Radiograph of a cross slice, 1 cm. thick, of the body of the uterus and a portion of a large subserous myoma with its pedicle. Nullipara, aged 31; arteries injected with bismuth. The uterus contains several small subserous and intramural myomata. The large subserous tumor (22 cm. in diameter), arose from the posterior wall of the uterus a little to one side of the median line, and has a rich arterial supply. A small subserous myoma, 1.3 cm. in diameter, is attached to the anterior uterine wall. Its nutrient vessels are small and have very little influence on the arterial circulation of the uterus. The main nutrient artery of the larger tumor, a peripheral branch of an arcuate artery, together with the latter, is greatly enlarged. The arcuate artery of the opposite side, which anastomoses with it, is also enlarged. The greater portion of the blood stream from the uterine arteries, especially the one from which the chief nutrient artery arises, is diverted from the uterus to the tumor. The radial arteries of uterus are apparently not increased in size and numbers.

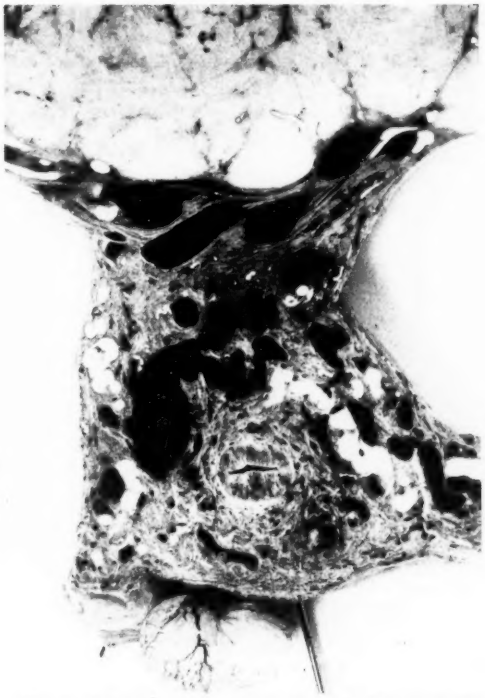


Fig. 8. Influence of the tumor shown in Fig. 7 on the venous circulation of the uterus (menstruation normal but profuse). Photograph of the slice shown in Fig. 7; veins injected with ultramarine blue. The white dots are arteries, containing bismuth, which have been cut across. Uterus removed during the interval stage of the menstrual cycle. Note the dilated veins and sinuses in the pedicle of the tumor and in the peripheral zone of the uterus near the pedicle. The radial zone is but little affected. The endometrium is thickened. A portion of the venous plexus of the peripheral zone of the uterus is converted into venous channels to convey the venous blood from the tumor to the veins between the layers of the broad ligament. The "venous congestion" is apparently active, and, being mainly in the peripheral zone, alters very little the circulation of the endometrium. Menstruation in this patient was always profuse, never excessive, and not increased lately.

these tumors apparently have an arterial blood supply, although I have seen a few very small ones in which it could not be detected in the gross specimen; this may have been due to faulty technique or the section through the tumor may not have exposed any of its vessels. Its nutrient artery, a radial or peripheral branch of an arcuate artery, surrounds the tumor with its branches, and the latter penetrate the substance of the tumor. Intramural myomata of this size are nearly always less vascular (arterial) than the surrounding myometrium. I have usually been unable to find any vessels in their substance filled with the venous injection mass. These tumors apparently do not appreciably alter the arterial circulation of the uterus as a whole unless in large numbers, when the uterine

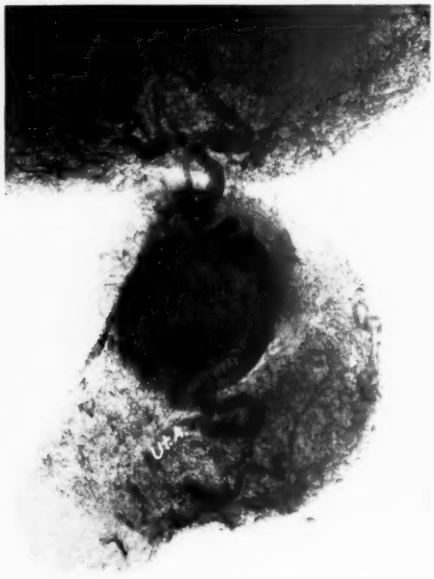


Fig. 9. Large subserous myoma. Changes in the arterial circulation of the uterus. X 1. Radiograph of one half of the uterus (sagittal section), and of the lower portion of the tumor and its pedicle; arteries injected with bismuth. Nullipara, aged 45.

The tumor, 10 cm. in diameter (the lower portion is shown), arose from posterior wall of the fundus to one side of the median line. A small subserous tumor is situated just below it. The larger tumor is very vascular, and its nutrient artery arises from one uterine artery which is larger than normal, and the greater portion of its blood stream is diverted from the uterus to the tumor.

Fig. 10. Influence of the tumor shown in Fig. 9, on the venous circulation of the uterus (menstruation normal, moderate). Photograph of a sagittal section of the specimen; veins injected with ultramarine blue. The white dots are arteries, containing bismuth, which have been cut across. Uterus removed during the interval stage of the menstrual cycle. Note the dilated veins and sinuses in the pedicle of the tumor and the upper portion of the peripheral zone of the uterus. The radial zone is but little affected, the endometrium (a small portion shown in the section) is apparently unaltered. A portion of the venous plexus of the peripheral zone of the uterus is converted into venous channels for conveying the venous blood of the tumor to the uterine and ovarian veins. The "venous congestion" is evidently active, not passive, and did not alter the circulation of the endometrium; i. e., the uterus was able to control its venous circulation. Menstruation in this patient had always been normal and moderate in amount.

artery may appear a little larger. Locally the artery supplying its nutrient artery may seem a little larger, and mechanically they displace the arteries in the surrounding myometrium. The venous plexus of the myometrium about the very small tumors is not appreciably changed, but about many of those over 1 cm. in diameter there is often a localized, or even a general dilatation of this plexus, and this increases with the size of the tumor. Sometimes when the larger tumors of this group are present or there are a number of tumors, there is an increase in the size of the uterine wall, due in some instances to an actual hypertrophy of the myometrium and in others to a dilatation of the venous plexus of the myometrium, or both factors (Fig. 13).

A study of the injected specimens suggests that these tumors usually do not greatly interfere with the circulation of the uterus and do not alter menstruation, and clinically experience confirms this. Even those with a generally hypertrophied venous plexus of the myometrium do not necessarily have menstrual disturbances (Fig. 13). On the other hand they may indirectly cause menorrhagia or metrorrhagia (Figs. 11 and 12). In 18 uteri

Fig. 11. Small intramural myomata associated with a polypoid condition of the endometrium (menorrhagia). X 1. Photograph of a sagittal section of the uterus. Para, aged 40; hysterectomy for uncontrollable uterine bleeding (drugs and curettage had failed to relieve the patient); patient bleeding slightly at the time of the operation. Arteries injected with Venetian red and veins with ultramarine blue. The arterial injection mass did not escape into the uterine cavity, but some of the venous mass did, and appeared as an oozing from the surface of the endometrium. The uterus is slightly enlarged and contains several small intramural myomata, chiefly in the peripheral zone, one (M) shown in the illustration. The endometrium is hypertrophied and presented an irregular polypoid surface. The venous plexus of the myometrium is not hypertrophied. While small intramural myomata apparently do not alter the circulation of the uterus in the majority of cases, they may possibly sometimes cause changes leading to abnormal bleeding, one of which may be a polypoid condition of the endometrium. Compare with the next illustration.

removed for obscure uterine bleeding, small intramural myomata were found in 16. The two in which they were not found were nulliparas, as were also two of the 16. In 4 of the 16, discrete polypi were found in addition to the myomata; in two others there was a polypoid condition of the endometrium. In the remaining ten, the myomata were the only apparent pathological condition present.

Fig. 12. Small intramural myomata associated with an atrophied endometrium (menorrhagia). X 1. Photograph of a sagittal section of the uterus. Para, aged 41; hysterectomy for uncontrollable uterine bleeding (drugs and curettage had failed to relieve the patient); patient bleeding at the time of the operation. Arteries injected with Venetian red and veins with ultramarine blue. The arterial injection mass did not escape into the uterine cavity, but some of the venous mass did, and appeared as an oozing from the atrophic rough endometrium. The uterus is slightly enlarged and contains several small intramural myomata, two shown in the illustration. The endometrium is atrophied and rough. The uterine cavity is not closed. The venous plexus of the myometrium is not dilated. A condition of uterine inefficiency exists. The uterus is unable to prevent the venous blood from escaping into the uterine cavity. Small intramural myomata may possibly cause this condition. The atrophied rough endometrium may be but a stage in the abnormal menstrual cycle, the other stage being represented by a polypoid condition of the endometrium, as shown in the preceding illustration.

In none of the 16 cases did any of the myomata encroach upon the endometrium. In two of the specimens the uterus was soft, flabby and the plexus of the myometrium hypertrophied,

Fig. 13. Small peripheral intramural myomata. Changes in the venous circulation of the uterus (menstruation, normal and moderate). X 1. Radiograph of a median sagittal slice, 3 mm. thick, of the uterus and the myoma. Para, aged 36; uterus removed for chronic pelvic peritonitis in interval stage of menstrual cycle; veins injected with bismuth. The uterus is enlarged, the endometrium hypertrophied, and the venous plexuses of both endometrium and myometrium are dilated. Compare with Fig. 3. In spite of the hypertrophied endometrium and increased amount of venous blood within the uterus, menstruation was moderate in amount and normal; i. e., the uterus was able to control its increased venous circulation and prevent an excessive flow into the uterine cavity.

Fig. 14. Large peripheral intramural myoma; its influence on the arterial circulation of the uterus (menstruation, normal and moderate). Slightly reduced in size. Radiograph of a cross slice, 1 cm. thick, of the body of the uterus and the myoma. Nullipara, aged 38; arteries injected with bismuth. The tumor, 10.5 cm. in its long diameter, arose in the peripheral zone of the anterior uterine wall, and has grown away from the uterus. The uterine artery supplying the tumor is enlarged and the excess over the normal is diverted to the tumor, which is very vascular, as in Figs. 7 and 9. The tumor has had very little or no effect on the arterial supply of the radial zone of the uterus and the endometrium. In this slice there is no evidence of any communication between the arteries of the uterus and the tumor. For the nutrient arteries of this tumor, see Figs. 10 and 11 of previous article.

in the others the uterus was hard, the walls thickened, and the plexus of the myometrium compressed. They represent the two types of uteri associated with abnormal bleeding described by Theilhaber:[1] the one due to muscular weakness, i. e., the musculature is unable to regulate an increased hyperæmia due to any cause, or *hypoplasia muscularis uteri;* the other due to an apparent predominance of fibrous tissue, the *myofibrosis uteri* found especially in parous women approaching the menopause. It is not my purpose to discuss the cause of bleeding in these cases, as the literature on this subject is voluminous, contributions having been made by several writers in this country, as Findley, Anspach, Smith, Goodall, and others, but to suggest

[1] Blutungen und Ausfluss aus dem Uterus. Verlag von E. Rheinhardt, München, 1909.

Fig. 15. Influence of the myoma shown in Fig. 14 on the venous supply of the uterus. Photograph of the slice shown in Fig. 14; veins injected with ultramarine blue; uterus removed during the interval stage of the menstrual cycle. The chief changes in the venous supply of the uterus are in the peripheral zone, where portions of the venous plexus of the myometrium are converted into venous channels for conveying the venous blood from the tumor, as in Figs. 8 and 10. The endometrium is hypertrophied. Menstruation in this patient was normal and moderate in amount. The uterus was able to control its increased arterial and venous blood supply and prevent an excessive flow of venous blood into the uterine cavity.

Fig. 16. Upper surface of the fundus of the uterus and the myoma shown in preceding illustration. Photograph showing the dilated veins over the surface of the tumor which convey the blood from the tumor to the venous channels shown in Fig. 14. These veins are sometimes injured or become eroded and intraperitoneal hæmorrhage occurs, as has been reported in the literature.

that small intramural myomata may in some way contribute to its development. From the study of the injected specimens, muscular inefficiency seems to me to be the most important factor, as it would fail to prevent the reflux of blood from the plexus of the myometrium into that of the endometrium and would fail to occlude the uterine cavity.

Fig. 17. Dilatation of venous plexus of the myometrium about an intramural myoma. Slightly reduced in size. Radiograph of a cross slice, 3 mm. thick, through the fundus of the uterus and myoma, above the uterine cavity. Veins injected with bismuth; para, aged 28. There is a marked dilatation of the venous plexus of the myometrium.

Fig. 18. Dilatation of venous plexus of myometrium and endometrium. Same specimen shown in the preceding illustration (menorrhagia). Radiograph of a cross slice, 3 mm. thick, through the body of the uterus below the tumor. Uterus removed in the interval stage of the menstrual cycle. There is a general venous active hyperæmia, with dilatation of the venous plexuses of the myometrium and endometrium, apparently caused by the myoma. The hypertrophied endometrium may be caused by this hyperæmia. Menstruation had become much more profuse for four months prior to operation; i. e., the uterus was unable to control this hyperæmia, and an excessive amount of venous blood escaped during the menstrual flow.

MEDIUM SIZE AND LARGE INTRAMURAL MYOMATA

Changes Caused by Them in the Circulation of the Uterus

Medium size and large intramural myomata were found in 76 specimens; in 60 of these they were the principal variety present, while in 16 a more important variety or condition was associated with them, as submucous myomata in 11, adenomyoma in 3, sarcoma in 1, and carcinoma of the cervix in another. Sixty of these specimens were used in the study of this phase of the subject. In 3 only one tumor was found, while in 57 multiple intramural myomata were present.

These specimens have been arranged in three groups:

1. Those not encroaching upon the uterine cavity.
2. Where a single tumor encroaches upon the uterine cavity.
3. Where multiple tumors encroach upon the uterine cavity.

Medium size and large intramural myomata not encroaching upon the uterine cavity.—These were found in many of the specimens, but only in 6 were they the principal condition present, and in all 6 other smaller tumors were present. They develop in the peripheral zone of the uterus, and are nourished by peripheral arteries which supply the tumor as the smaller tumors are nourished. There is usually one principal nutrient artery, and secondary ones may be present which communicate with branches of the principal one; in addition there is sometimes found a communication between arterioles in the periphery of the tumor and those in the surrounding myometrium, as has been described in the previous article. The venous supply of these tumors is usually scanty, and in some apparently lacking. Tumors of this size contain a larger number of arteries than the surrounding myometrium, and sometimes are so vascular that they appear as an arterial angioma rather than a myoma (Fig. 14).

A study of the injected specimens shows that these tumors contain many tortuous vessels filled with arterial blood and that the veins within the tumor are usually scanty (Fig. 15); this suggests that the circulation of the tumors is very sluggish. Nevertheless, there is a demand for more blood to be carried to and away from the uterus, and therefore the extrinsic uterine arteries and veins are usually increased in size. One uterine artery is sometimes larger than the other, namely, the one nourishing the largest myoma or the greatest number. The arcuate artery from

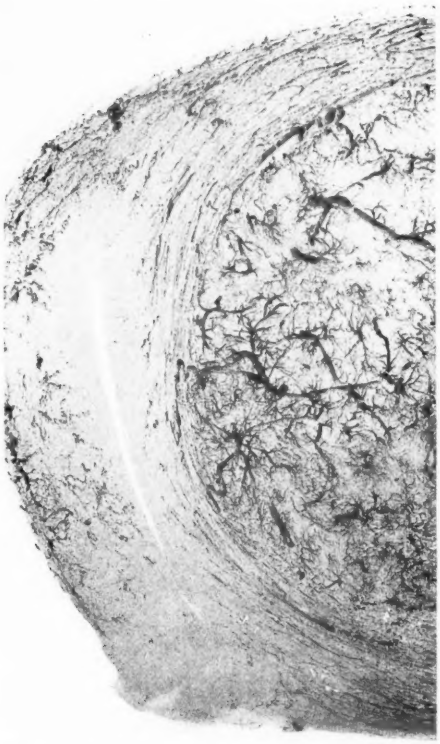


Fig. 19. Large radial intramural myoma; changes in the arterial circulation of the uterus. X 1. Radiograph of a sagittal slice, 5 mm. thick, of the body of the uterus and portion of the myoma. Para, aged 49; arteries injected with bismuth. The tumor, 10 cm. in diameter, arose in the radial zone of the posterior uterine wall and caused a symmetrical enlargement of the uterus. The uterine arteries, not shown in this slice, were enlarged and more blood was carried to the uterus and tumor, but the excess over the normal was carried to the tumor through its nutrient arteries. In addition there is a communication between arterioles in the periphery of the tumor and those in the surrounding myometrium. The tumor apparently has had very little influence on the arterial supply of the uterus, except that the radial arteries supplying the endometrium nearest the tumor have to curve around the tumor to reach it. The diminution of the arterial supply of the uterine tissues is possibly due to the age of the patient — 49 years.

Fig. 20. Influence of the myoma shown in the preceding illustration on the venous circulation of the uterus (menstruation, normal and moderate). Photograph of the surface of the slice shown in the preceding illustration; veins injected with ultramarine blue; uterus removed during the interval stage of menstrual cycle. The myoma has caused an enlargement of the uterus, i. e., a hypertrophy of the walls and dilatation of the venous plexus, especially about the periphery of the tumor and between it and the endometrium. The latter is hypertrophied, and the portion nearest the tumor is thicker and more vascular (venous) than the rest of the endometrium. In spite of the hypertrophy and increased vascularity of this portion of the endometrium (venous congestion), and the dilated venous plexus between it and the myoma, menstruation had always been normal and moderate in amount. The uterus was able to control this venous congestion and prevent an excessive flow of venous blood at the menstrual period.

which the principal nutrient artery arises is also increased in size. As in large subserous myomata, the excess arterial supply of the uterus as a whole is diverted to the tumor or tumors. The tumor mechanically causes a displacement of the arteries in the surrounding myometrium. The myometrial venous plexus about the tumor is always dilated. As the latter condition exists about the entire circumference of the tumor, it is principally one of active and not passive venous hyperæmia. A study of the six cases shows that the disturbance in circulation is chiefly a local one, and in four of the six specimens it

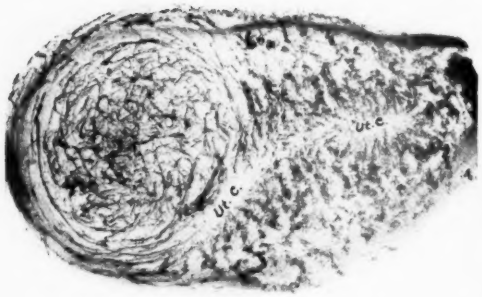


Fig. 21. The influence of a medium size radial intramural myoma on the arterial supply of the endometrium over it. Slightly reduced in size. Radiograph of a cross slice, 4 mm. thick, of the fundus of the uterus and myoma. Para, aged 49; arteries injected with red lead. The myoma, 3 cm in diameter, is situated in the radial zone of one cornu and encroaches upon the uterine cavity. The myoma pushes to one side the radial arteries about it and thus interferes with the arterial supply of the endometrium over it. The more it encroaches upon the uterine cavity the greater this interference, and therefore, the more anæmic the endometrium over it.

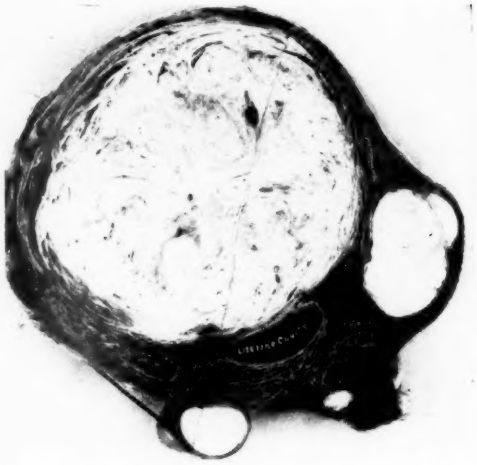


Fig. 23. Large radial intramural myoma, menstruating endometrium (menorrhagia). X ½. Photograph of a cross section of the uterus. Nullipara, aged 34; arteries injected with Venetian red and veins with ultramarine blue; uterus removed the second day of the menstrual flow. The largest myoma, 8 cm. in diameter, is situated in the radial zone of the posterior uterine wall and is beginning to encroach upon the uterine cavity. The arterial injection mass did not escape into the uterine cavity, but the venous mass did. The cervix was clamped prior to the injection of the venous mass; therefore the uterine cavity is distended with this mass. For further details see next illustration.

was confined mainly to the peripheral zone of the uterus, and the circulation of the radial zone and endometrium was unaltered. The uteri apart from the tumors were only slightly increased in size. We would expect that in these four cases menstruation would not be affected by the tumor or tumors, and it was not. In two patients menstruation had apparently been altered by the myomata. In one it had become more profuse; many medium size intramural myomata were present in the peripheral zone of the uterus, and these may have mechanically embarrassed the flow of blood from the radial zone; the uterus as a whole was increased in size. Here again muscular inefficiency may have been at fault, i. e., more blood in the radial zone than the musculature of the uterus could handle. The other patient had both menorrhagia and metrorrhagia, and the specimen apart from the myoma was typical of *myofibrosis uteri.*

Single medium size or large intramural (radial) myomata which encroach upon the uterine cavity.— These were found in 44 specimens as the principal condition present. They were also found in other specimens but were overshadowed by some other condition, as a submucous myoma, sarcoma, carcinoma, etc. In three of the 44 specimens only one, myoma was present. In the remaining 41, other but less important myomata were found.

These tumors had all developed in the radial

Fig. 22. (See frontispiece.) Large radial intramural myoma encroaching upon the uterine cavity (menorrhagia). X 1. Colored photograph of a lateral sagittal section of the uterus and myoma. Nullipara, aged 40; arteries injected with Venetian red and veins with ultramarine blue; uterus removed in the interval stage of the menstrual cycle. The myoma is situated in the radial zone of the posterior uterine wall, and has caused a symmetrical enlargement of the body of the uterus. The uterine walls are hypertrophied and their venous plexus dilated. The tumor encroaches upon the uterine cavity, and the endometrium over it and opposite it is anæmic. On the other hand the endometrium not encroached upon, either directly or indirectly, is hypertrophied; it is from the latter portion of the endometrium that the menstrual flow for the most part arises. Menstruation was very profuse and prolonged; i. e., the uterus was unable, in this case, to control its increased vascularity and prevent an excessive flow of venous blood into the uterine cavity. The venous injection mass did not escape into the uterine cavity because the patient was not flowing at the time of the operation.

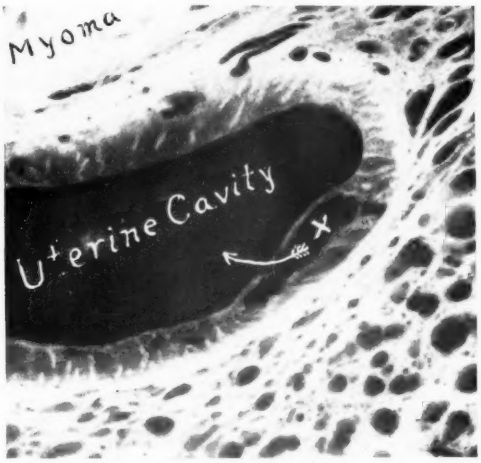


Fig. 24. Menstruating endometrium. X 4. From photograph shown in preceding illustration. Enlargement, X 4, of a portion of the uterine cavity and surrounding tissues. The cavity is distended with the venous injection mass, cervix clamped. A hæmatoma is present at X and the overlying endometrium has ruptured, permitting the escape of the venous injection mass into the uterine cavity. The glands of the endometrium are easily discernible.

zone and were all nourished by radial arteries. Their blood supply and circulation are similar to those developing in the peripheral zone. They are intrauterine growths in the true sense of the term. The body of the uterus as a whole is hypertrophied. The degree of uterine hypertrophy apparently varies greatly in different specimens and seems more marked in the relatively young women. In those at or past the menopause it is apparently not as evident. The increased thickness of the wall is due principally to two conditions: first, an actual hypertrophy of its tissues, and secondly a dilatation of the venous plexus of the entire myometrium, most marked where the pressure is least. The arterial supply of the entire uterus is increased, and much of the excess over the normal is diverted to the tumor or tumors. The uterine veins are also enlarged. The tumors cause a local displacement of the arteries in the surrounding myometrium, and the venous plexus of the myometrium immediately about the tumor is often dilated. As these tumors approach the uterine cavity they alter its

Fig. 25. Radial intramural myoma, menstruating endometrium (menorrhagia). X 1. Photograph of a median sagittal section of the uterus. Para, aged 41; arteries injected with ultramarine blue and veins with bismuth; uterus removed the first day of the menstrual flow. The myoma, 5 cm. in diameter, is situated in the radial zone of the posterior uterine wall and encroaches upon the uterine cavity. The endometrium over the tumor and directly opposite it is atrophied and anæmic. The endometrium not encroached upon is vascular, and the menstrual flow arises from this, as shown by the extravasation of the bismuth (white) into the tissues of the endometrium and thence into the uterine cavity. Menstruation was very profuse and prolonged; i. e., the uterus was unable to prevent an excessive flow of venous blood in the uterine cavity.

size and shape and usually make it larger, but may occasionally make it smaller, as when a moderate size tumor develops in the fundus or lateral wall of the uterus.

Let us first consider uteri containing tumors which, while encroaching upon the uterine cavity, are still separated from it by

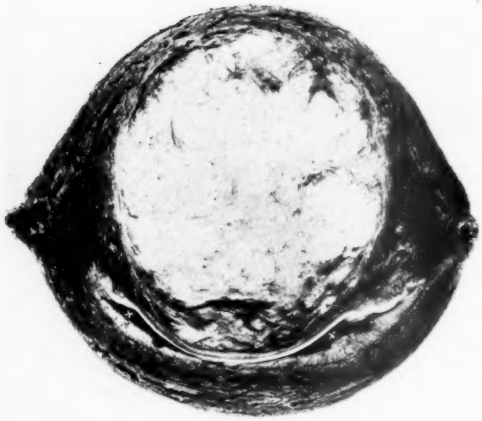


Fig. 26. Large radial intramural myoma, menstruating endometrium (menorrhagia). X ¾. Radiograph of a cross slice of the uterus. Nullipara, aged 35; veins injected with bismuth; uterus removed the first day of the menstrual flow. The endometrium over the tumor is anæmic and atrophied, while that lateral to the tumor and not compressed by it is hypertrophied; the uterine cavity opposite the latter (X and X) is filled with the injection mass (black) which escaped from the superficial portion of the venous plexus of the hypertrophied endometrium. The venous plexus of the myometrium is dilated. Menstruation was profuse and prolonged; i. e., the uterus was unable to control its increased vascularity and prevent an excessive flow of venous blood into the uterine cavity during the menstrual flow.

a zone of myometrium. We find in the radiographs that the radial arteries curve around the tumor, and while distorted in their course are still able to reach the endometrium lining the cavity nearest the tumor. The venous plexus of the myometrium between the endometrium and tumor is usually dilated. The uterine cavity is usually broadened or lengthened, or both. The endometrium nearest the tumor is sometimes thickened and other times thinned. The latter condition may be due to pressure or interference with its blood supply. Conditions found in some of the injected specimens would seem to support the theory advanced

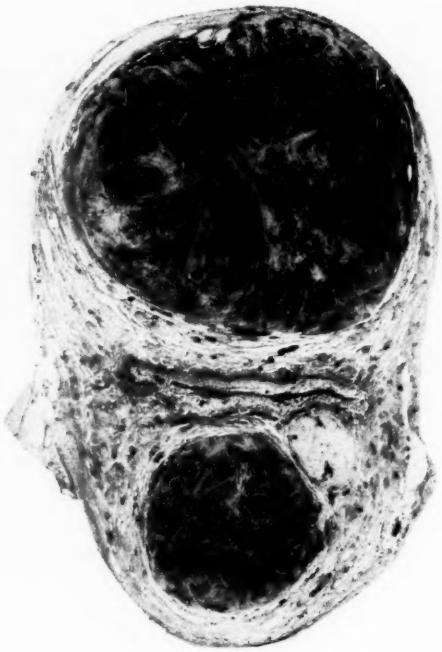


Fig. 28. Two large radial intramural myomata, menstruating endometrium (menstruation, slightly increased in amount). Slightly reduced in size. Photograph of a cross section of the uterus and myomata. Nullipara, aged 32; arteries injected with ultramarine blue and veins with bismuth; uterus removed the first day of the menstrual flow. A large myoma is situated in the radial zone of each uterine wall. The myomata have a very rich arterial blood supply (black). The venous plexus of the myometrium (white) is dilated, especially about the myomata. The endometrium (half-way between the myomata) is hypertrophied (its blood supply is not interfered with) and there is an extravasation of the venous injection mass (white) into its tissues. Menstruation had recently become slightly more profuse and prolonged; i. e., the uterus was beginning to be unable to prevent an excessive flow of venous blood into the uterine cavity during the menstrual flow.

by Clark,[1] viz., that such tumors mechanically compress the veins more readily than the arteries, and therefore cause a local conges-

[1] Johns Hopkins Bull., 1899, x, 11-20.

Fig. 27. (See frontispiece.) Two large radial intramural myomata approaching the uterine cavity (menstruation, moderate). X 1. Colored photograph of a median sagittal section of the uterus and myomata. Nullipara, aged 37; arteries injected with Venetian red and veins with ultramarine blue; uterus removed in the interval stage of the menstrual cycle. A large myoma is situated in the radial zone of each uterine wall; the venous plexus of the myometrium is dilated, especially about the periphery of the tumors, between them and the uterine cavity. The endometrium is hypertrophied and injected (venous). Menstruation was normal and moderate in amount; i. e., the uterus was able to control its "venous congestion" and prevent an excessive flow at the menstrual period.

Fig. 29. Same specimen shown in preceding illustration. Radiograph of a cross slice, 7 mm. thick, of the uterus and myomata; photograph of the surface shown in preceding illustration; veins injected with bismuth. This shows the scarcity of veins in the myomata (compare with its arterial supply shown in preceding illustration), and the great dilatation of the venous plexus of the myometrium about the tumors. There is an extravasation of the injection mass into the tissues of the endometrium.

Fig. 30. From same specimen shown in the two preceding illustrations. Radiograph of the upper slice of the specimen, showing the dilated venous channels of the myometrium spread over the upper surface of each tumor.

tion of the portion of the endometrium over the tumor, and hence menorrhagia results, but the history of these cases do not entirely support this view. While menorrhagia occurs in some of them, menstruation in others is normal (Fig. 20); and menorrhagia is much less apt to occur in this group than in the one about to be described, where the portion of the tumor encroaching upon the uterine cavity is covered only by the endometrium, and that portion of the endometrium is anæmic. While the local congestion, when it is present, may be a contributory factor in making the menstrual flow more profuse, it is not the chief one, and we are forced to explain the bleeding when it occurs in this group as being due mainly to a condition of uterine inefficiency. The uterus is unable to control the great venous hyperæmia which exists and prevent an excessive flow of venous blood at that time. We find identical anatomical conditions in two specimens; i. e., great venous hyperæmia of both myometrium and endometrium, and especially marked between the tumor and the uterine cavity, yet in one the menstruation is unaltered and in the other menorrhagia or metrorrhagia exists. In 8 specimens where the tumor was separated from the endometrium by a zone of myometrium, only three gave a history of menorrhagia.

The next group, where the tumor encroaches more upon the uterine cavity, represents a later stage of the preceding one and included 36 specimens. In this group the myoma is separated from the uterine cavity by a thin capsule of myometrium or the endometrium alone. I have included in this group all

Fig. 31. Multiple radial intramural myomata encroaching upon the uterine cavity, arterial supply of endometrium (menstruation, recently more profuse). X ¾. Radiograph of a median sagittal slice, 4 mm. thick, of the uterus. Para, aged 45; arteries injected with red lead. The myomata, M, M, M, encroach upon the uterine cavity, and the endometrium over them is atrophied and anæmic; the myomata push to one side and intercept the radial arteries supplying this portion of the endometrium. At E, E, E, the radial arteries are able to reach the endometrium, there is no pressure, and the endometrium is hypertrophied. Menstruation was beginning to become more profuse; i. e., the uterus was beginning to lose control of its increased vascularity.

Fig. 32. Arterial supply of hypertrophied endometrium, not encroached upon by myomata. Same specimen as the preceding. X ¾. Radiograph of a lateral sagittal slice, 4 mm. tnick, taken lateral to the myomata shown in the preceding illustration. The endometrium is hypertrophied; its arterial supply is not only not interfered with but is apparently increased in amount.

those in which less than one half the circumference of the tumor projected into the cavity. When more than this occurred they were included with the submucous tumors. The vascular changes in the myometrium are the same as in the preceding group, except for the thin zone which is sometimes present between the tumor and the endometrium. This zone in the preceding group was richly supplied with venous blood, while in the present group it is usually anæmic. The endometrium over the tumor is also thin and anæmic. The radiographs of specimens when the arteries are injected with bismuth show that the tumor mechanically interferes with the arterial supply of this portion of the endometrium (Fig. 21). The radiographs of specimens where the veins are injected show that this portion of the endometrium is also poorly supplied with veins (Fig. 22; see frontispiece), the rich venous plexus of the endometrium having disappeared and being replaced by a fine network of veins. Here and there a large vein may be present, just as we find large veins extending over the surface of a subserous tumor. Histologically [1] the glands are few in number, atrophied or entirely lacking. In extreme cases the endometrium covering the tumor is similar in its vascularity to the peritoneum covering the subserous variety.

The vascularity of the endometrium of the uterine wall opposite the tumor varies according to the size of the tumor and changes in form of the uterine cavity. When the tumor

[1] Beautifully shown in the illustrations in Kelly and Cullen's book, Myomata of the Uterus, W. B. Saunders & Co., 1909.

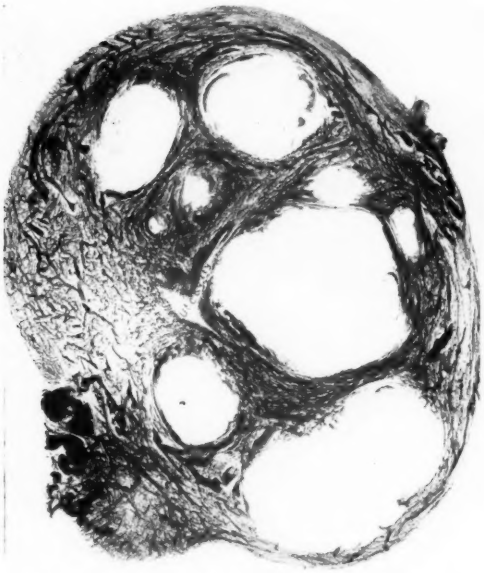


Fig. 33. Multiple radial intramural myomata encroaching upon the uterine cavity (menorrhagia). X ⅔. Radiograph of a cross slice, 4 mm. thick, of the uterus and myomata. Nullipara, aged 27; veins injected with bismuth; uterus removed in interval stage of menstrual cycle. Nine radial intramural myomata appear in this section. The plexus of the myometrium is dilated, the uterine cavity is distorted, and the endometrium in places hypertrophied. Menstruation was prolonged and profuse; i. e., the uterus was unable to prevent an excessive flow of venous blood into the uterine cavity at the menstrual period.

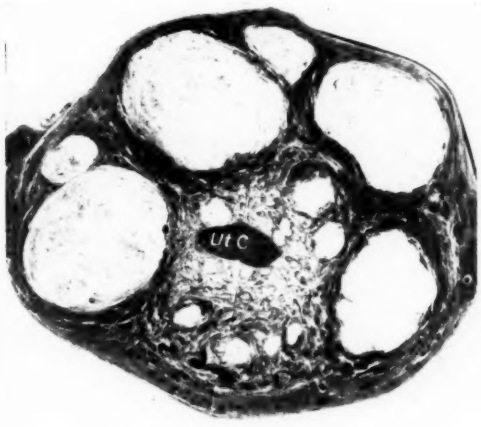


Fig. 34. Multiple radial intramural myomata (sligh metrorrhagia). X ⅔. Photograph of a cross section of the uterus. Nullipara, aged 46; veins injected with ultramarine blue and arteries with Venetian red; uterus removed at the menopause. Slight irregular bleeding was present at the time of the operation. Cervix clamped before injecting the venous mass, and the uterine cavity is distended with this mass; i. e., the bleeding was venous. The marked dilatation of the venous plexus of the myometrium, especially about the large myomata, is shown. Many small myomata are situated in the radial zone about the uterine cavity. The endometrium everywhere was atrophic (menopause). The last regular menstrual flow occurred six months before the operation; menstruation had been moderate in amount, but the patient had had irregular "spotting" since the menopause. The injection mass escaped from the atrophied endometrium; i. e., the uterus was unable to control its venous circulation.

is small, the opposite wall and its vascularity are very little changed. In large tumors, with a corresponding increase in size of the uterine cavity, the uterine wall opposite the tumor is thinned, the course of the radial arteries in this portion of the wall are more oblique than normal, and they are also separated further from each other. The venous plexus of the myometrium where pressure is greatest is compressed. The endometrium covering this portion of the uterine wall is often thinner than usual and anæmic. The thinning of this portion of the endometrium, I believe, is due not only to mechanical pressure and a pulling out of the uterine wall, but also to an interception of its blood supply.

Now let us consider the portions of the endometrium not encroached upon by the tumor. The situation of these portions varies with the situation and size of the tumor. Take as an example a tumor 5 cm. in diameter situated in the center of the posterior wall of the uterus. We find that the endometrium is thickest above and below the tumor and at the sides. The arterial supply of these portions is not interfered with, and the venous plexus is usually greatly hypertrophied. The blood supply of the endometrium covering these portions of the myometrium is not only not diminished but often apparently is increased; the radial arteries supplying it are sometimes apparently larger and even more numerous. The endometrium is always thicker than elsewhere in the specimen. In the majority of the cases it is thicker than normal, and sometimes there is marked hypertrophy. It was found hypertrophied in 24 of the 36 specimens. In the remaining

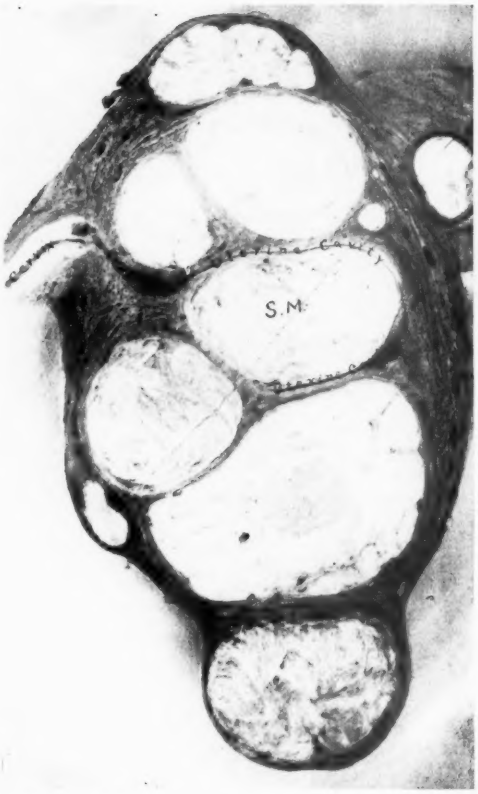


Fig. 35. Submucous myoma, and multiple intramural and subserous myomata (menorrhagia). X ½. Photograph of sagittal section of the uterus; arteries injected with Venetian red and veins with ultramarine blue. Nullipara, aged 46; uterus removed during the interval stage of the menstrual cycle; menstruation profuse and prolonged. The submucous myoma (S. M.) projects into the uterine cavity for over half its circumference. The endometrium over it and opposite it is anæmic and atrophied. The endometrium not encroached upon by the tumors, directly or indirectly, is hypertrophied.

Fig. 36. Hypertrophied endometrium lining uterine cavity not encroached upon by myomata. X 4. Enlargement, X 4, of a portion of the hypertrophied endometrium shown in the preceding illustration. The endometrium is greatly thickened; glands are very abundant, i. e., the tortuous white streaks; and the tissues are well supplied with venous blood. The endometrium covering the tumors is atrophied, anæmic, and devoid of glands. It is from the former portion of the endometrium that the menstrual flow arises and in this instance was very profuse.

12 it was thicker than elsewhere in the specimen, but not actually hypertrophied. Three of these 12 were past the menopause; and the phase of the menstrual cycle when the uterus was removed, and the fact that some of them were operated upon soon after a prolonged flow, may account for the thinness of the entire endometrium in these specimens. The venous plexus of these portions of the endometrium is usually also hypertrophied, and the venous channels uniting the plexus of the endometrium with that of the myometrium are often larger than normal. The hypertrophy of the endometrium is due not only to its apparent increased arterial supply and venous congestion, but I believe it is also due to the fact that there is not only room for it to grow, but there is a necessity for it to fill in the spaces (depressions) caused by the irregularities in the uterine cavity. This endometrium is rich in glands.

From a histological study of the injected specimens we would suppose that when menstruation occurs it would take place, not from the endometrium over the tumor, which is lacking in glands and a venous plexus so necessary for the flow, but from the endometrium not encroached upon by the tumor, which not only contains glands and a plexus,

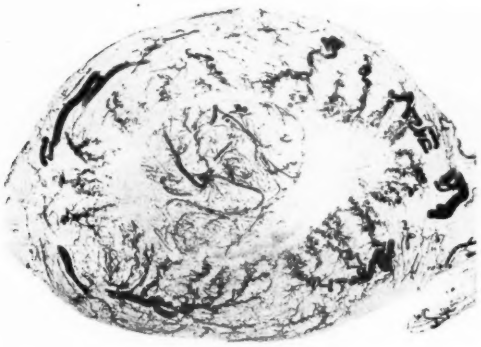


Fig. 37. Submucous myoma, arterial circulation of the uterine tissues, especially the endometrium (menstruation recently slightly more profuse). Slightly reduced in size. Radiograph of a cross slice, 3 mm. thick, of the uterus and submucous myoma. Nullipara, aged 39; arteries injected with bismuth. A submucous myoma arose in the fundus and protruded into the uterine cavity. Several small intramural myomata were also present. The submucous myoma was very vascular and the arterial supply of the uterus and tumor increased. The endometrium anterior and posterior to the tumor is atrophied by pressure, while lateral to it, where pressure is not exerted, it is hypertrophied as though it filled in the gaping uterine cavity. Menstruation had been very little altered by the submucous myoma, although the patient thought it had recently been slightly more profuse, and occasionally a slight "spotting" was present in the intervals. Uterus removed for chronic pelvic peritonitis.

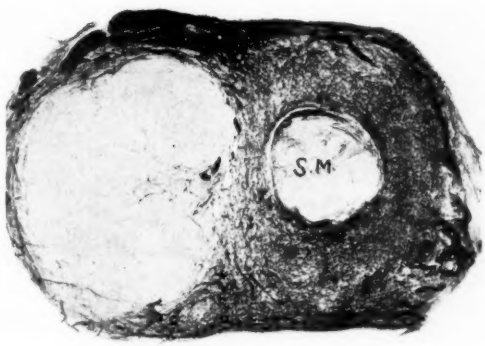


Fig. 38. Submucous and intramural myomata, venous circulation of the uterus (menorrhagia). X ¾. Radiograph of a cross slice, 3 mm. thick, of the uterus and two myomata. Para, aged 39; veins injected with bismuth; uterus removed at onset of menstrual flow. The uterine cavity is distended with the submucous myoma (S. M.). Dilated veins are present over the surface of the myoma as in subserous myomata, but the bleeding did not arise from these in this instance. See next illustration.

but both often hypertrophied, thus suggesting increased functional activity. This plexus also communicates with a dilated myometrial plexus containing more blood than normal and united with it by larger channels. I have studied 3 specimens which were removed and injected the first day of menstruation (Figs. 23, 24, 25 and 26). In all these the portion of the atrophied endometrium over the tumor apparently did not take part in menstruation, and the most active flow occurred from the places above described. I have studied other specimens removed from patients who were flowing irregularly at the time of the operation and found the same to be true. Unless the patient is actually flowing, or is about to flow, or has just ceased flowing, the injection mass will not escape into the uterine cavity. Changes in the venous plexus of the endometrium are essential for the flow, and these changes are usually initiated, in this group of cases, by the onset of menstruation, though the bleeding may continue for many days or even weeks afterwards. From a study of the injected specimens alone we would assume that the prolonged profuse menstruation so often seen in these cases was due to the hypertrophy of the endometrium, with its increased venous plexus, which, through larger channels than normal, communicated with a hypertrophied venous plexus of the myometrium. The clinical study of these cases showed that 6 of the 36 cases gave a history of normal menstruation, while in 30, menorrhagia or metrorrhagia was present. We must also bear in mind that uterine bleeding is the symptom which usually induces these patients to consult a physician and also influence the physician to advise an operation. Therefore, a greater proportion of those with bleeding are operated upon than those who are not bleeding, and the ratio of 30 to 6 does not represent the true ratio. When we study the specimens in these two groups, i. e., those with and without bleeding, we find the same anatomical conditions present in both groups. In fact, some of the patients with the thinnest endometrium had the most profuse bleeding. As stated before, the thickness of the endometrium varies with the individual, her age,

Fig. 39. Menstruating endometrium from same specimen as preceding. X 1. Radiograph of a cross slice, 3 mm. thick, of the body of the uterus near the fundus, and above the two myomata shown in the preceding illustration. The uterine cavity is filled with the venous injection mass, which escaped from the superficial portion of the venous plexus of the endometrium not encroached upon by the myomata, and here the endometrium is slightly hypertrophied. The uterus was unable to control its venous circulation.

and the period of the menstrual cycle when the uterus was removed — thickest just before menstruation, thinnest just after, and especially after a profuse flow.

Some of these cases do not bleed, and this is apparently because the uterus is able to control the flow, even though the uterus as a whole contains more blood and has to work under disadvantages; i. e., portions of the endometrium are hypertrophied, the venous plexuses of those portions and that of the myometrium are dilated, and the venous channels uniting the two are larger than normal, and the uterine cavity on account of its shape is difficult to close. On the other hand, many of these cases have menorrhagia or metrorrhagia, and this is due to the inability of the uterus to regulate the flow, which is due to many factors, and I believe chief among these are functional ones, especially muscular inefficiency.

The factors which might increase the flow are:

1. Increased ovarian activity, which cannot be detected anatomically, though the ovaries are sometimes enlarged. The myomatous uterus may stimulate the ovaries chemically and also through the increased vascularity of the uterine circulation.

Fig. 40. Submucous myoma presenting at the external os (slight irregular bleeding). X 1. Photograph of a sagittal section of the uterus, exposing the submucous myoma. Para, aged 51; veins injected with ultramarine blue and arteries with bismuth. The uterus also contained several small intramural myomata. The venous injection mass escaped from the superficial veins, over the surface of the myoma, at X, X, X, which had become eroded. The patient gave a history of menorrhagia three years before, which gradually lessened, and lately there was slight irregular bleeding.

2. More arterial and venous blood for the uterus to handle and the possibilities of venous congestion, due to the greater volume of venous blood in the uterus and in the uterine and ovarian veins, and because the tumors themselves sometimes mechanically interfere with the return flow of blood.

3. Localized hypertrophy of the endometrium, where it is not directly or indirectly encroached upon by the tumor. This hypertrophy carries with it the possibility of increased functional activity, and I refer especially to glandular activity and the production of a ferment which would not only

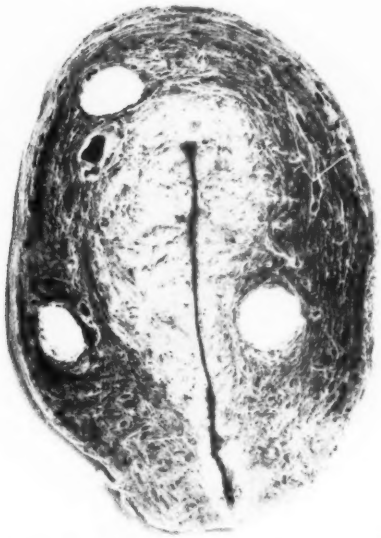


Fig. 41. Adenomyoma and small intramural myomata (menorrhagia). X 1. Photograph of median sagittal section of the uterus. Para, aged 48; arteries injected with Venetian red and veins with ultramarine blue; uterus removed during the interval stage of the menstrual cycle for bilateral ovarian cysts. Three small intramural myomata appear in this section; the entire uterine cavity, including each cornu, is surrounded by a diffuse adenomyoma. The endometrium was everywhere atrophic. The patient gave a history of very profuse and prolonged (abnormal) menstruation of four years' duration. Adenomyomata may sometimes cause menorrhagia.

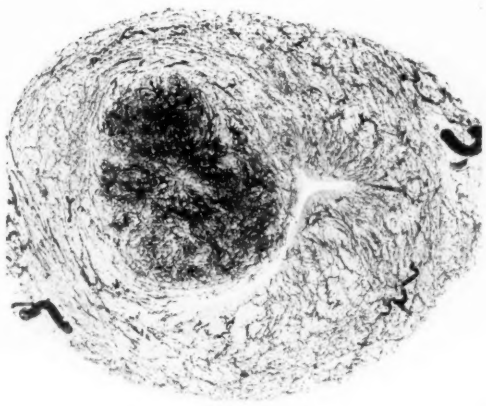


Fig. 42. Adenomyoma, and radial intramural myoma encroaching upon the uterine cavity. Arterial injection. (Menstruation, normal.) Slightly reduced in size. Radiograph of a cross slice, 4 mm. thick, of the body of the uterus near the fundus. Para, aged 48; arteries injected with bismuth; uterus removed during the interval stage of menstrual cycle for chronic pelvic peritonitis. The intramural myoma is very vascular, and the diffuse adenomyoma surrounding the greater part of the uterine cavity not encroached upon by the intramural myoma is more vascular than normal. The uterine cavity is distorted. The endometrium is not hypertrophied in any part. Adenomyomata, as other varieties of myomata, do not necessarily cause menorrhagia.

alter the venous plexus of the endometrium at the onset of menstruation but which might retard its subsequent repair.

4. Dilatation of the venous plexus of the localized hypertrophied portion of the endometrium, and that of the myometrium into which it empties and the venous channels between the two, making the control of the "protective" zone between the two more difficult.

5. Dilated veins sometimes present in the endometrium over the tumor, which may through pressure become eroded or may be acted upon by the products of the glands at the time of menstruation. (I have occasionally seen slight extravasation of the injection mass into the endometrium over the tumor, and can see how that bleeding may arise from this situation, but have never found any other proof of this.)

6. In an irregular uterine cavity which is difficult to close.

Any one of the above mentioned factors might prolong or make more profuse the menstrual flow, and yet all these conditions are sometimes apparently present in patients in whom menstruation is unaltered. I believe that while all of the above factors contribute to disturbances in menstruation, we are forced to admit that the failure of the uterus to control the menstrual flow in these cases is in a large measure functional. This functional disturbance might be ovarian, in the endometrium, or in the myometrium, and my studies have led me to support Theilhaber's views that muscular inefficiency is the most important single cause of the abnormal bleeding. Theilhaber has shown that the muscular fibres of the myomatous uterus are smaller in patients with a history of bleeding than in others.

The type of bleeding caused by intramural myomata encroaching upon the uterine cavity

Fig. 43. Adenomyoma and large intramural myoma. (Menstruation, moderate, normal.) X 1. Photograph of median sagittal section of the uterus and portion of large intramural myoma. Para, aged 49; arteries injected with Venetian red and veins with ultramarine blue; uterus removed in post-menstrual stage of menstrual cycle. A large intramural myoma, 14.5 cm. in its long diameter, is present in the posterior uterine wall; only a part of it appears in the illustration. The myoma in the anterior uterine wall is an adenomyoma, and there is beginning adenomyoma about the upper portion of the uterine cavity. The venous plexus of the myometrium is dilated. The endometrium is hypertrophied except over the adenomyoma. Some of the venous injection mass escaped into the cavity. Uterus removed just after the menstrual flow. In spite of the increased vascularity of the uterus and the presence of a large intramural myoma and adenomyoma, menstruation was moderate in amount and normal; i. e., the uterus was able to control its venous circulation.

is a profuse or prolonged menstruation, or both profuse and prolonged. Sometimes intermenstrual bleeding occurs, and I think that it is but a further index of broken compensation. I have not had the opportunity to study a sloughing myoma, but would expect that when such a specimen was injected the injection mass would escape from the tumor and hence would be arterial rather than venous, as occurred in all the specimens studied in this series who were flowing at the time of the operation and where the injection mass escaped from the endometrium.

Multiple medium size and large intramural myomata encroaching upon the uterine cavity.—This group should be a subdivision of the

Fig. 44. Adenomyoma and small intramural myoma, venous injection (severe menorrhagia). X $\frac{2}{3}$. Radiograph of a cross slice, 5 mm. thick, through the fundus of the uterus. Para, aged 49; veins injected with bismuth; uterus was bleeding slightly when removed. An adenomyoma (apparently developing in each cornu) surrounded the greater portion of the uterine cavity; a small intramural myoma is present in the anterior wall. The venous plexus of the myometrium is dilated. The endometrium is everywhere atrophic. Some of the venous injection mass escaped into the uterine cavity, which gapes open. The patient gave a history of severe menorrhagia, varying in amount and duration and often lasting several weeks. Last flow ceased seven weeks before the operation, and patient had just started to flow again. The uterus was unable to control its venous circulation.

preceding one. The changes are similar to the preceding one. The areas of hypertrophied endometrium are found in the crevices between the tumors and wherever the nutrition of the endometrium is not interfered with by the tumors intercepting it or from pressure (Figs. 31 and 32). The uterine cavity is often greatly distorted and therefore more difficult to be kept enclosed (Fig. 33). Ten such specimens were found. Two gave a history of normal menstruation, 7 of menorrhagia, and 1 of metrorrhagia. In 9, areas of hypertrophied endometrium were found, and in 1 (the one with metrorrhagia) the endometrium was everywhere atrophied (the patient's age was 50).

SUBMUCOUS MYOMATA

Changes Caused by Them in the Circulation of the Uterus

Sixteen specimens were obtained where a submucous myoma was the principal condition present. In addition, 3 of the 12 speci-

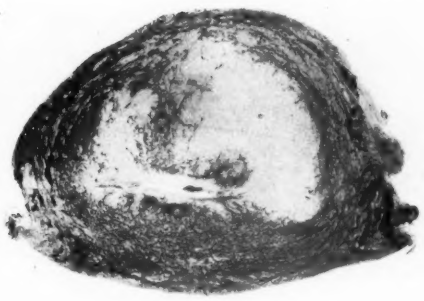


Fig. 45. Adenomyoma, venous injection (menstruation, normal; always profuse). X 1. Radiograph of a cross slice, 5 mm. thick, through the body of the uterus. Para, aged 43; veins injected with bismuth; uterus removed for chronic pelvic peritonitis in the post-menstrual stage of the menstrual cycle. An adenomyoma (apparently developing in each cornu) surrounded the upper portion of the uterine cavity. Small intramural myomata were also present. The venous plexus of the myometrium is dilated. The endometrium is not hypertrophied. The uterus was able to control its venous circulation.

Fig. 46. Adenomyoma, almost occluding the uterine cavity. Small intramural myoma, venous injection. (Menstruation, normal, profuse.) X 1. Nullipara, aged 28. The uterus was removed for chronic pelvic peritonitis. The uterine cavity is very small, being almost occluded by the adenomyoma surrounding it. Otherwise, the legend of Fig. 45 will apply to this.

mens with adenomyomata also had submucous myomata. I have included as submucous myomata all myomata protruding into the uterine cavity for half or more of their circumference. They represent a later stage of the preceding variety. Of these 16 specimens, more than one submucous myoma was found in 5, and in all intramural myomata of various sizes were found.

The changes caused by the sessile submucous myomata are similar to those found in the intramural tumors already considered. Pedunculated submucous myomata were found in 8 specimens and one of these presented at the external os. The endometrial surface of the pedunculated myomata simulates very closely the serous surface of the pedunculated subserous variety. The endometrial surface is devoid of true endometrium, and the endometrium covering the uterine cavity in contact with the tumor is usually compressed, while the endometrium lining the cavity and not in contact with the tumor is always comparatively thicker and often hypertrophied. We would suppose that menstruation would occur mainly from that portion of the endometrium containing glands and having a good blood supply and not compressed by the tumor, and such is the case (Figs. 38 and 39). The menstrual history of these cases showed that all but one gave a history of menorrhagia or metrorrhagia as in the menstrual history of intramural variety with menorrhagia, and it was not a constant symptom; i. e., it did not occur with every menstruation.

As stated, these tumors do not necessarily cause bleeding, but apparently cause it in a larger percentage of the cases than the preceding. They represent a later stage of the disease. They are more apt to have metrorrhagia, which is also a manifestation of a later stage of the disease. The metrorrhagia in some of these cases may come from rupture of the veins over the surface of the tumor. I was able to demonstrate this in one of my specimens (Fig. 40). We know that intraperitoneal hæmorrhage may occur from the rupture of dilated veins over a subserous myoma. In a pedunculated submucous tumor the return of the venous blood is often interfered with and the surface of the tumor is exposed to trauma and irritation.

ADENOMYOMATA

Changes Caused by Them in the Circulation of the Uterus

This variety of myoma was found in twelve specimens, and in each specimen other varieties of myomata were also present. In four,

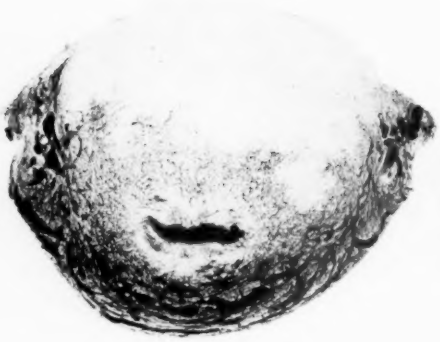


Fig. 47. Adenomyoma, apparently separate from the endometrium lining the uterine cavity. Venous injection. (Menstruation occasionally excessive.) X 1. Radiograph of a cross slice, 5 mm. thick, of the uterus. Nullipara, aged 37; veins injected with bismuth; uterus removed for bilateral hæmorrhagic ovarian cysts during the interval stage of the menstrual cycle. The adenomyoma was in the posterior uterine wall and was very adherent to the rectum. It apparently is not continuous with the endometrium lining the uterine cavity. Small intramural myomata are also present. The venous plexus of the myometrium is dilated. The endometrium is of normal thickness. The menstrual flow varied in amount and occasionally was excessive; i. e., the uterus was sometimes unable to control its venous circulation.

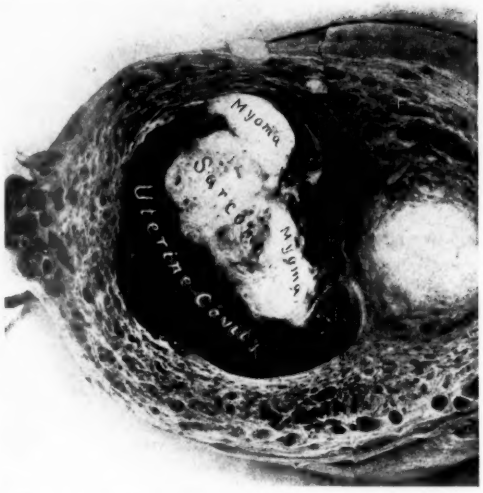


Fig. 48. Sarcoma, arising in a submucous myoma, both arteries and veins injected (metrorrhagia arising three years after the menopause) X ½. Photograph of a cross section of the uterus. Nullipara, aged 57; arteries injected with Venetian red and veins with ultramarine blue; menopause at 54, metrorrhagia three years later. Patient died six months after the operation with symptoms of pulmonary metastases; autopsy not obtained. A submucous myoma is present, with sarcomatous "degeneration." A large intramural myoma is also present; the lower portion of this is shown in the illustration. The cervix was clamped during the injection; the venous mass did not escape into the uterine cavity but the arterial did; i. e., *the bleeding arose from the tumor, which is arterial, and not from the endometrium, which is venous.*

the patients were operated upon for uterine myomata and adenomyoma was found associated with the other varieties. In three the uterus was removed with ovarian cysts, two bilateral and one unilateral (the opposite ovary having been previously removed). Three uteri with adenomyomata were removed for chronic pelvic peritonitis, one for ectopic pregnancy, and another for tuberculosis. In all twelve specimens small ordinary intramural myomata were found. In three uteri, large ordinary intramural myomata; and in another three, the submucous variety, in addition to the small intramural tumors mentioned and adenomyoma were found. The following injection masses were used in these twelve specimens: in one, ultramarine blue for the arteries; in three, Venetian red for arteries and ultramarine blue for the veins; in one, bismuth for arteries and ultramarine blue for the veins; in the remaining seven, the veins only were injected, and these with bismuth.

The study of the blood supply of these tumors is difficult, because they are not as sharply defined from the myometrium as the other variety. They are apparently more vascular (arterial) than the surrounding myometrium (Fig. 42), and are poorly supplied with veins, but not as poorly supplied as the ordinary myoma (Figs. 44, 45 and 46).

The study of the influence of these tumors on the circulation of the uterus I have found difficult, because other varieties were present in the same specimen. In five of the twelve specimens, the adenomyoma was the predominating variety present, while in the remaining seven other varieties were more prominent and the adenomyoma was relatively insignificant (Figs. 42 and 43). These tumors cause an increased vascularity of the uterus and also a dilatation of the venous

Fig. 49. Adenocarcinoma of the body of the uterus (small intramural myomata also present), venous injection (metrorrhagia arising two years after the menopause). X 1. Photograph of a cross section of the fundus of the uterus. Nullipara, aged 55; arteries injected with bismuth and veins with ultramarine blue; menopause at 51; metrorrhagia of two years' duration. Small intramural myomata are also present in the uterus, though none appears in this section. The carcinoma occupies the greater portion of the posterior uterine wall. The growth contained very few veins—the dark area in the center is blood in the tumor which was not washed out. The venous injection mass did not escape into the uterine cavity, but the *arterial did*. See next illustration.

Fig. 50. Same specimen shown in preceding illustration, arterial injection. Radiograph of a cross slice, 3 mm. thick; photograph of the same shown in the preceding illustration; arteries injected with bismuth. The arterial supply of the uterus is diminished, due to patient's age; i. e., after the menopause. The carcinoma has an arterial blood supply, but less than the myometrium. *The bleeding* arose from the carcinoma, and *is of arterial, not venous, origin*, as when it occurs from the endometrium.

plexus of the myometrium, as do the intramural myomata of their size (Figs. 41, 44, 45 and 46). Their relation to the endometrium is interesting. In two of the specimens the adenomyoma was in no place continuous with the endometrium (Fig. 47). In the remaining ten, it was continuous with it, and in four surrounded nearly the uterine cavity. I recently operated upon a patient (not in this series) in which an adenomyoma was present in each tube at its origin from the uterus. Four of the twelve specimens suggested the simultaneous development of the tumor in each cornu (Figs. 44, 45 and 46). In my specimens the endometrium lining the uterine cavity over these tumors was thinner and less vascular than the endometrium lining other portions of the uterine cavity (Fig. 43).

In five, menstruation was unaltered by the myomata (including adenomyomata) present. In two of these menstruation was moderate in amount, while in three it was profuse but not excessive. A radiograph of a cross slice of the uterus of one of these with moderate menstruation is shown in Fig. 43, and the other, with a similar menstrual history, contained small discrete intramural myomata, in one of which areas of mucosa were found. The three with profuse but normal menstruation are shown in Figs. 42, 45, and 46. Five gave a history of menorrhagia; two of these specimens also contain a discrete ordinary submucous myoma and intramural myomata in addition to the adenomyoma. In the other three the adenomyoma was apparently responsible for the menorrhagia, although bilateral ovarian cysts were present in two of these three, and small ordinary intramural myomata were also present. These three are shown in Figs. 41, 44, and 47. Two gave a history of metrorrhagia, one profuse, the other scanty. In the one which was profuse a polyp and small intramural myomata were present; in the one with occasionally "spotting" an ordinary submucous myoma, small intramural myomata, and tuberculosis of the endometrium were present in addition to the adenomyoma.

Only two of the twelve patients were flowing at the time of the operation, and only one of these lends itself to the study of the source of the bleeding in adenomyomata, as the other contained an ordinary submucous myoma, had tuberculosis of the endometrium, and had been curetted a few days before. The first one (Fig. 44) showed that the venous flow escaped from the endometrium over a portion of uterus not involved by the tumor.

This subject needs further investigation, but the clinico-pathological study of my twelve injected specimens shows that these tumors do not necessarily disturb menstruation — five of the twelve did not — and that when menorrhagia or metrorrhagia is present it may be due to an ordinary myoma, as three of these had ordinary submucous myoma in addition to the adenomyoma or some other well-known possible cause of these symptoms. On the other hand, I believe that adenomyomata sometimes give rise to abnormal uterine bleeding, as in the cases shown in Figs. 41 and 44. These cases suggest that the etiology of the bleeding is similar to that in other myomata and apparently does not arise from the tumor, but as in others is due to the uterine insufficiency, i. e., the inability of the uterus to control its increased venous circulation and prevent an excessive flow of venous blood at the menstrual period.

SUMMARY OF CASES CLASSIFIED ACCORDING TO THEIR MENSTRUAL HISTORY AND CONDITIONS PRESENT

Forty-seven of the patients gave a history of not having had any disturbance in menstruation. Of these, 22 had small intramural and some small subserous myomata; 17, medium size and large intramural myomata; 5, adenomyomata and small intramural myomata; 2, large subserous and small intramural myomata; and 1, a submucous and small intramural myoma.

Sixty-four gave a history of profuse menstruation, often prolonged, i. e., the so-called menorrhagia as the predominating type of abnormal bleeding. Thirty-nine of these had intramural tumors encroaching upon the uterine cavity as the apparent cause; in 10, a submucous tumor was present; small intramural tumors not encroaching upon the uterine cavity were found in 9; adenomyoma with other varieties of myomata were found in 5; small intramural tumors with a polyp were found in 2.

Thirty-nine gave a history of irregular bleeding, i. e., metrorrhagia as the predominating symptom. Carcinoma of the cervix with intramural myomata was found in 8, carcinoma of the body of the uterus with myomata in 5; polypi and small intramural tumors in 5; small intramural myomata not encroaching upon the uterine cavity, 4; large intramural myomata, 3; adenomyomata with other forms of myomata, 2; tubal pregnancy and myomata, 3; incomplete abortion with myomata and infection (one puerperal, other probably gonorrhœal), 2; hydatiform mole with myomata, 1; sarcoma, 2.

This grouping shows that any one variety may or may not alter menstruation, and that the bleeding present, especially if of the metrorrhagic type, is often due to some other condition.

THE INFLUENCE OF UTERINE MYOMATA ON THE AGE OF THE MENOPAUSE

Myomata, except very small ones, increase the amount of blood in the utero-ovarian circle. The ovarian arteries and veins are hypertrophied as well as the uterine. The excess over the normal amount of blood is apparently for the most part diverted to the uterus, and there diverted to the tumor. The usual physiological arterial sclerosis incident to the approaching menopause would probably affect a larger vessel less quickly than a smaller one. We would expect that an efficient blood supply to the ovaries would be maintained at a later age in women with myomata than those without, and, therefore, the functional activity of the ovaries in such women would persist longer, even though the excess over the usual amount of blood is apparently diverted to the uterus. The same would also hold true for the uterus, especially if it contained intramural myomata; i. e., we would expect that the endometrium or portions of it would maintain its circulation at a later age than in the non-myomatous uterus. The generally accepted view is that the menopause is delayed in women who have myomata, and my studies confirm this. Sixteen of the 150 patients had passed the menopause; the earliest age at which this occurred was 45 (had two very small intramural myomata), the next earliest 48, and the latest 56. The average age of the menopause in the sixteen patients was 51+ years.

SARCOMA AND MYOMA OF THE UTERUS

Sarcoma was found in only two specimens. The first patient, a nullipara, was 50 years of age and had been bleeding for 6 months. Small intramural myomata were present, and the uterine cavity was filled with a growth which protruded partially from the cervix and extended through the uterine walls and invaded the adjacent structures. It was impossible to state if it was primarily sarcoma or sarcoma had developed in a myoma. This specimen was so badly mutilated in its removal that it could not be satisfactorily injected. The patient died six months later, and at autopsy an extensive local recurrence was found, and metastases were present in the lungs.

The second patient, a nullipara, was 57 years of age. Irregular uterine bleeding was of six months' duration, and began two and a half years after the menopause. The uterus contained several small myomata, a large intramural myoma, and a submucous myoma. A small area of the submucous tumor showed sarcoma. The blood supply of this area seemed similar to that of the myoma in which it had developed. It contained vessels filled with the arterial injection mass, but did not show any filled with the venous mass. The *arterial and not the venous mass* escaped into the uterine cavity (Fig. 48); i. e., the bleeding was of arterial and not venous origin, as occurs in uterine bleeding arising from the endometrium. The patient died six months after the operation, with symptoms of bronchitis and pleurisy (tapped and fluid removed from pleural cavity), thus suggesting pulmonary metastases. An autopsy was not obtained.

CARCINOMA OF THE UTERUS AND MYOMATA

Eleven uteri were removed for carcinoma of the cervix while collecting this material and injected as a routine procedure. Myomata were found in eight specimens; in seven the myomata were small and of the intramural type. In the eighth small myomata were present, and in addition a large intramural myoma and a myoma of the cervix; the latter was of the submucous type and protruded into the vagina. The youngest patient was 32, and the oldest 57; the average age of the eleven patients was 43+ years.

Five uteri were removed for carcinoma of the body, and in all, small intramural myomata were found. The youngest patient was 50 and the oldest 62; the average age of the five patients was 57+ years.

It is impossible to draw any conclusions from such a small number of cases, but they emphasize the frequency with which myomata are found associated with carcinoma of the uterus and, especially, with carcinoma of the body, to which references may be found in the literature.

It is very difficult to obtain a satisfactory injection of either the arterial or venous supply of the cervix of a uterus removed at operation, because the injection mass escapes from many small cervical vessels which are injured at the operation, and the injection of all my specimens on this account was incomplete. Nevertheless they showed that carcinoma of the cervix has an arterial blood supply, apparently less than the normal cervix, and as in myomata it is difficult to demonstrate any veins. The *arterial injection mass* and *not the venous* escaped from the growth during the injection of the specimen. The necrosis incident to the growth leads to destruction of portions of the cancer and injury to its arteries, with subsequent hæmorrhage of *arterial, not venous, origin*. My studies of the blood supply of carcinoma of the cervix are unfinished and must be reserved for a later publication.

The injection of uteri containing carcinoma of the body is easily accomplished, and my specimens showed that this type of growth has an arterial blood supply, but less than the myometrium, and that they are also deficient in veins. In every instance, the injection mass which escaped from the growth was *arterial* and not *venous* (Figs. 49 and 50).

OVARIAN CYSTS AND UTERINE MYOMATA

We are aware that the ovaries are responsible for the changes in the uterus leading up to the menstrual flow, and that it is possible that they are of importance in the regulation of the amount and duration of the flow. Therefore, disturbances in the circulation of the

uterus may influence the functional activity of the ovaries and lead to changes in the ovaries. The ovaries of patients having myomata often are apparently normal, even in those causing marked changes in the circulation of the uterus. At times they are enlarged, the so-called "myomatous ovaries," and at times cysts are present. I have not studied the ovaries of all my specimens histologically, as in many instances they were not removed or only one was removed. In seventeen instances ovarian cysts were found, and in twelve of these the operation was undertaken for ovarian cysts and the myomata were of secondary importance. Carcinomatous ovarian cysts were found in two instances, dermoids in two, bilateral hæmorrhagic ovarian cysts in eight, Graafian follicle cysts in three, bilateral infected ovarian cysts in one, and adenocystoma in one. Of the 150 cases, 17 were associated with ovarian cysts, and 8 — i. e., nearly half of these — were associated with bilateral ovarian cysts containing a thick bloody material in the cavities of the cysts. Of the 17 specimens with ovarian cysts, 5 were associated with adenomyoma. Of 12 cases of adenomyoma of the uterus (also containing other forms of myomata), 5 of them were associated with ovarian cysts, as compared with 138 cases of myomatous uteri not containing adenomyomata and associated with ovarian cysts in only 12 instances. The ovarian cysts associated with the adenomyomata were not all of the same kind. In four of the five the cysts were bilateral, and the one that was unilateral had had a previous operation in which an ovary had been removed for a small cyst. The cysts in two instances were apparently Graafian follicle cysts, in two others the cysts contained the hæmorrhagic material mentioned above and in the fifth bilateral infected cysts were present. Of the 17 cases, only 6 gave a history of menorrhagia or metrorrhagia, and in all 6 myomata of a type apt to cause uterine bleeding were found.

The patients with dermoid, cancerous cysts, and cystadenoma, associated with myoma, were probably accidental associations, and the same may be true of the others. The significance of these findings, especially the apparent frequency of adenomyoma associated with ovarian cysts, is based on too small a number of cases from which to draw any conclusions.

SUMMARY

As a result of ovarian activity, the uterus undergoes periodic changes which manifest themselves clinically by the menstrual flow. The flow is preceded by changes in the venous plexus of the endometrium, permitting the escape of blood into the tissues of the latter. The duration of the flow and the amount of blood lost is probably dependent upon many factors, such as changes in the endometrium, the time necessary for the repair of the altered endometrium, the degree of venous congestion of the uterus and the ability of the uterus to control its venous circulation. These factors are not entirely evident in anatomical conditions which we can detect, but are probably controlled mainly by the functional activity of the uterus, the ovaries, and, possibly, other structures and the interrelation between these. I have demonstrated that menstruation is mainly, if not entirely, a venous flow and can occur only when there are changes in the venous plexus of the endometrium, permitting the blood to escape. As there are not any valves in the uterine veins, the duration of the flow and the amount of blood lost is dependent upon several factors, and, especially, the ability of the uterus to control its venous circulation, i. e., to prevent an excessive escape into the uterine cavity when there is a leak in the venous plexus of the endometrium, as occurs at the menstrual flow. The most important factor in controlling the venous circulation would be the muscular efficiency of the uterus and the regulation of the same, however it may be accomplished.

Small subserous myomata are relatively anæmic and do not have any appreciable influence on the uterine circulation.

Large subserous myomata are very vascular (arterial), and cause a hypertrophy of the uterine artery from which their nutrient artery arises, and thus more blood is carried to the uterus and tumor, the excess over the normal being diverted to the tumor. More venous blood is carried back to the uterine

and ovarian veins. The chief arterial and venous changes are in the peripheral zone of the uterus; the radial zone and endometrium are but very little affected, and menstruation is usually not altered.

Small intramural myomata are less vascular than the myometrium and apparently have very little influence on the circulation of the uterus, and usually menstruation is not altered. As cases sometimes occur with a history of menorrhagia or metrorrhagia in which small intramural myomata are found, these cases suggest that those tumors may in some way lead to uterine inefficiency, especially muscular inefficiency, with a resulting loss of control of the venous circulation of the uterus.

Intramural myomata over 2.5 cm. in diameter are usually more vascular arterially than the myometrium, but less vascular venously. Some of the large tumors are so very vascular that the injected specimen appears more like an arterial angioma than a myoma. The greater the arterial supply of the tumor, the greater the increase in the arterial supply of the uterus containing it; but, as in the subserous variety, at least, the greater part of the increase over the normal is diverted from the uterus to the tumor.

The venous plexus of the myometrium is always dilated, and this is most marked about the periphery of the tumor, and especially in places where the pressure is least. The venous uterine congestion is apparently mainly an active one, and the uterine walls are apparently hypertrophied in order to control it. The endometrium, if not encroached upon by the tumor or tumors, is often hypertrophied, and its venous plexus is also dilated. Menstruation may or may not be affected, and when excessive or abnormal bleeding occurs it is apparently due to a loss of uterine efficiency; i. e., the uterus is unable to control its dilated venous plexuses, and, there not being any valves, it is unable to prevent the escape of an excessive amount of blood into the uterine cavity at the menstrual flow. The regenerative changes following menstruation, i. e., menstrual involution, is also sometimes retarded. This may be due to changes in the endometrium, which are possibly dependent upon the disturbance in circulation.

Intramural myomata which encroach upon the uterine cavity alter the shape of the cavity and intercept or push to one side the radial arteries which supply the endometrium over the tumor, and this, with the pressure exerted by the myoma, causes an atrophy and anæmia of this portion of the endometrium. The endometrium directly opposite the tumor may also be thinner and less vascular than normal, due to the pressure of the tumor. The endometrium not directly or indirectly encroached upon is always thicker and more vascular, and is often actually hypertrophied and its venous plexus more dilated than normal. The condition of the endometrium in any specimen is dependent upon the age of the patient and the phase of menstrual cycle when the uterus was removed. The menstrual flow arises mainly from the endometrium not directly or indirectly encroached upon by the tumor; i. e., the endometrium, which has an abundant blood supply, contains glands and is usually hypertrophied. The atrophied, anæmic endometrium over the tumor which has a poor blood supply, and in which the glands are few in number or entirely absent, takes a very small part or none at all in the menstrual flow. Disturbances in menstruation may or may not occur. The profuse flow, when it occurs, is only in a measure dependent upon the increased amount of venous blood in the plexuses of the myometrium and endometrium, the larger channels uniting the two plexuses, and the hypertrophy of portions of the endometrium and the distortion of the uterine cavity making it more difficult to close. This disturbance is apparently due more to the failure of the uterus to control the venous blood under these adverse circumstances, and a retardment of the regeneration or repair of the endometrium. Two specimens may appear the same, yet in one, menstruation is normal, and in the other, excessive; nor can we discern anatomically why both should not give the same menstrual history. Occasionally, dilated veins in the endometrium over the surface of the tumor may become eroded and give rise to abnormal bleeding, but the usual and chief source is

from the portion of the endometrium described above.

Submucous myomata represent a later stage of the intramural variety, and the veins over the surface of the tumor are more apt to become injured or undergo degeneration than those over the intramural tumors. The source of the profuse menstruation is usually the endometrium not encroached upon by the myoma. Menstruation is more often abnormal, but may be normal.

I have not studied a sufficient number of specimens of adenomyomata to state definitely the source of bleeding when this variety is present. Only twelve uteri were encountered containing these tumors, and in all twelve other types of uterine myomata were also present. These cases showed that *disturbances in menstruation are not necessarily present*, and when they occur they may be due to changes caused by other myomata in the specimen. On the other hand adenomyomata may cause menorrhagia or metrorrhagia, just as other intramural myomata encroaching upon the uterine cavity do. When abnormal bleeding is present, it is apparently dependent upon the same factors as other types of myomata, and the excessive flow does not arise from the tumor itself. This variety must be reserved for further study.

My studies have led me to believe that when the bleeding arises from the tumor itself, due to sloughing or sarcomatous changes, it would be arterial (the tumors have a rich arterial supply), and not venous, as occurs from the endometrium.

TYPHO-TUBERCULOUS TUBO-OVARIAN ABSCESS

By WM. D. FULLERTON, Ph. B., M. D., Cleveland, Ohio

THE case I have to report has proved to me to be one of great interest, the finding of both the typhoid and tuberculous infections being accidental and entirely unsuspected. Then also, on looking up the available literature on the occurrence of typhoid infections of the female genital organs, I find but three cases reported definitely, one each by Gans (1), Koch (2), and Dirmoser (3), and the bacteriological study of the case of the last author leaves a doubt as to whether the organism recovered was really the B. typhosus. More often have I found typhoid pelvic infections merely alluded to and the statements made that such infections may occur, but no instances cited. Henning (4) states that hæmorrhagic salpingitis may accompany the acute exanthemata, and that toxic irritation may give a mild salpingitis, typhoid fever being one of the etiological factors for the toxæmia. Dürck (5) believes that acute infectious oöphoritis may be caused by the B. typhosus. Von Henkelom-Sregenbeck (6) in his work on "Pathogenesis of Diseases of the Adnexa," states that typhoid may be an etiological factor. Lebedinsky, Skrobansky (7) and others, have shown that with the acute infectious diseases, among them typhoid fever, the ovaries undergo changes varying from cloudy swelling to acute parenchymatous inflammation, similar to the changes in other parenchymatous organs in these infections, and furthermore, that neither the severity nor the duration of the disease has any relation to the amount of degeneration found; mild infections giving marked changes and vice versa. These changes if mild, clear up as elsewhere, but if severe and extensive, may, as Lebedinsky states, affect the reproductive activity or give rise to chronic trouble with these organs.

Dobbin (8) has reported a case of puerperal infection from which B. typhosus, streptococcus and staphylococcus were all recovered. The bacteriological study of this case makes it certain that the typhoid bacillus was recovered, and Dobbin believes that the patient was infected at the time of delivery by a midwife, the patient occupying same room and bed in which her husband had died a short

time previously of typhoid fever. Hirst (9) states that he has at different times recovered the typhoid bacillus from the puerperal uterus, enabling him to make a diagnosis of typhoid fever when sepsis was suspected.

From this summary it will be seen that pyogenic typhoid infections of the female pelvis are either rare or seldom observed and almost never reported. The case I have to present is as follows:

Mrs. F., Gyn. No. 4486, a married German woman of 25, entered the Lakeside Hospital August 15, 1912, complaining of "pain in the right side and back for the previous three months, and of feeling very weak and tired."

Family history. Unimportant.

Past history. Always healthy as a child. When twelve years of age a thyroid enlargement was noticed which increased gradually in size during the next nine years, then, four years ago, she had a thyroidectomy in Prague. Neither during the past on careful questioning or at present on careful examination, were any of the symptoms of Graves' syndrome discovered, except a moderate exophthalmos, which the patient said she had always had. The patient on admission had a rounded, symmetrical, fluctuating, subcutaneous tumor, 3 cm. in diameter, which seemed to arise from the thyroid isthmus. There had been no cough, hæmoptysis, night sweats, tachycardia or gastric distress. though she had lost twenty pounds in weight during the previous three months. Bowels were regular daily. Menstruation began at seventeen years, was regular every four weeks, flowed moderately for three days, the flow being accompanied by a great deal of pain, mostly in the lower part of her back. She had been married ten months, no children or miscarriages. Her husband had gonorrhœa four years previous to his marriage, was carefully treated and apparently cured. The patient gave no history of venereal disease nor did she admit any of their signs or symptoms. She had never had any pelvic trouble until her present illness.

Present illness. Fourteen weeks previous to her admission the patient had pain in her right lower quadrant, which her physician diagnosed appendicitis. She refused operation. After two weeks' medical treatment, during which time her condition improved slightly, she suddenly became worse and called in another physician; then, three months prior to admission, the patient went to bed with a persistent bad headache which lasted for a week or more. At this time she had fever which persisted for slightly more than three weeks. Her bowels were loose and once she remembers having seen some blood with them. She was slightly delirious at times and had some slight burning on urination. She was kept on a liquid diet.

The pain in her right lower quadrant which had been continuous since her attack of typhoid, but which had gradually become much worse, with acute attacks many times during the day, had practically confined her to her bed and rendered her incapable of any exertion. The pain was not noticed at night, as she slept well.

Physical examination on admission. The patient was a rather poorly nourished woman, somewhat anæmic. The thorax was long and thin, with some flattening of the infraclavicular region, the depth of the supraclavicular fossa on the right side was greater than on the opposite side. Over the upper right side, expansion lagged slightly and was somewhat diminished. Vocal fremitus was increased and the percussion note was slightly higher pitched and dulled in tone.

Faint moist râles were heard during inspiration. The heart was somewhat enlarged though the sounds were clear. There was rather marked tenderness in the lower abdomen and some muscular rigidity.

Pelvic examination. The outlet was in good condition, the cervix crossed the axis of the vagina and was normal. The uterus was small, the fundus forward and fixed. On the right, extending down into the cul-de-sac, was a firm, hard mass, which seemed to have softened areas. The left side was also adherent. The physical examination was otherwise unimportant.

On admission the urine was normal; the W. B. C. 15400 to the cu. mm.; Hb. 70 per cent; B. P. 105 mm. Hg.; Temp. 100; pulse 98.

Operation. Two days after admission, a short median incision was made and the pelvic structures found densely adherent. Both tubes and ovaries formed pus sacs which ruptured on freeing the adhesions. The right broad ligament formed a phlegmon about 2.5 cm. in thickness, extending from the uterus to the pelvic wall. Both tubes and ovaries, with the phlegmon of the right broad ligament, were removed and the pedicles cauterized. The appendix was normal and removed. The abdomen was closed without drainage.

The patient made a fair recovery from her anæsthetic, nitrous oxide and ether, but by consulting her temperature chart it will be seen that the day following operation her temperature rose to 102.5. Her temperature varied from 99 to 102.5 for the next six days. Her wound was then dressed for the first time and was found to be broken down. Iodoform tape drains were inserted and thereafter the wound dressed daily. The day following the first dressing her temperature began to drop, the following day reaching 98.5. Then, except for an unexplained rise to 103.5 on the eleventh post-operative day, the temperature gradually sought a lower level, but continued to show a morning drop and evening rise.

The patient was discharged thirty-five days after the operation, the abdominal sinus still discharging slightly. I might add that now, seven months after her operation, the sinus is not entirely healed. Hygienic measures were advised and the patient has

gained twelve pounds in weight and feels very comfortable in every respect.

Pathological examination. In the gross, the specimens removed at operation were so inseparably bound and matted together as to be almost indistinguishable. Imbedded in the mass from the right side was a collapsed, thick walled abscess, the lining of which was thick, of a dirty white color, densely attached to the underlying tissue and very much roughened and inflamed. In the mass from the left side a differentiated portion of the tube was patent for 1.5 cm. and filled with pus. The surface of this mass at one place resembled the lining of the abscess on the right side.

Microscopically, the picture of both of the tubes and ovaries were the same and were as follows: *right tube* is much thickened, the villi of the lumen are destroyed and replaced by necrotic material and leucocytes. Here there are many epitheloid cells forming tubercles which contain numerous giant cells. The muscle walls are greatly infiltrated with small round cells, and the surface shows an abundant growth of granulation tissue in which there are a few necrotic areas. *Right ovary:* The tunica albuginea is thickened and the cortex shows a few primordial and Graafian follicles. There is an increase in fibrous tissue and a marked round-cell infiltration. The medulla and one side of the ovary are replaced by granulation tissue and necrotic material, through which are scattered many typical tubercles; surrounding the necrotic tissue there is an almost solid wall of round cells.

At operation, swab cultures were taken of the pus from the pelvic abscesses. Examination of the smears from these swabs showed a rather thick, short, bacillus, with rounded ends, and on staining with methylene blue I was particularly impressed by the irregularity in the staining and the presence of numerous polar bodies. The growth of these organisms on all ordinary media corresponded to that of the B. typhosus; in subculture they were much more regular in their staining. The organisms were actively motile, decolorized with Grams' stain, did not ferment glucose, and agglutinated completely in one hour with typhoid serum in a strength of 1–50. For this Widal reaction I am indebted to Dr. Keyser of the Lakeside Hospital.

With these facts, I doubt if anyone could doubt the specific types of this double infection. The question of which was primary and the probable mode of infection will be discussed later.

Now, since in them there are some points of similarity to my case, let me give a brief summary to the cases of Koch and Dirmoser referred to above. Koch's case was that of a woman of twenty-eight, who had had typhoid at fourteen. She came to the clinic and was diagnosed pelvic inflammatory disease. At operation the free fluid found in the pelvis was sterile, but mucopus from a cystic tubo-ovarian mass gave cultures of B. typhosus. That of Dirmoser was a woman of twenty who had had typhoid, the onset of which was five months previous to the onset of the symptoms of her present illness, which was one month previous to her admission. At operation the lower intestines were bound together and adherent to the anterior abdominal wall. A tumor the size of a child's head was adherent to the bladder in front, and attached to the right ovary, uterus and intestines. This tumor, a thick walled abscess, contained a greyish yellow, stinking pus. There was an abscess and pyosalpinx on the left side. Microscopically the pus showed no organisms, but cultures gave colonies of the typhoid-colon group, the organisms of which were fairly bacilli, stained Gram negatively, did not ferment sugars or produce an indol reaction, but did cloud broth. They were considered to be B. typhosus.

We are all aware of the frequency of post-typhoid suppurations and infections, in which the typhoid organisms are the etiological factor, such as osteomyelitis and the so-called typhoid spine, cystitis, cholecystitis, etc., and even circumscribed typhoid intercranial suppuration has been described.

With perfected technique, the constant finding of typhoid organisms in blood cultures in the early stage of the disease proves without a doubt that at this stage the disease is a septicæmia.

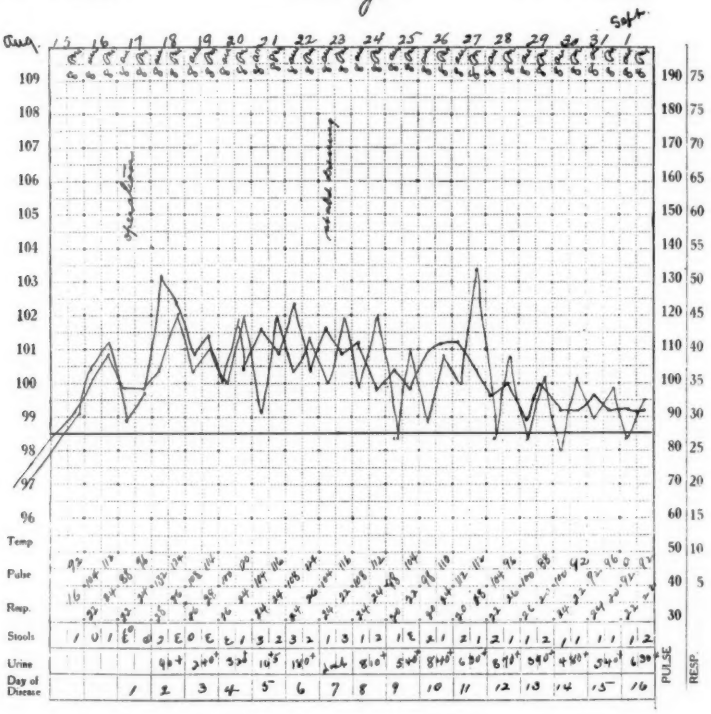
We know that the condition induced by one organism favors the growth of other pathogenic forms (10). Why, then, is it not reasonable to suppose that these organisms, finding their way as they do to all parts of the body, should not, on finding a focus which is already diseased and the resistance lowered, find there a point most suitable for multiplication?

Other modes of infection are possible, but I do not believe so plausible. For instance, the infection may have been an ascending one through vagina and uterine canal, the organisms coming from the perineum. There is, however, considerable evidence to show that except in cases of gonorrhœa or puerperal infection, this mode of infection rarely occurs.

No. 9486

THE LAKESIDE HOSPITAL

Name Mrs. F. Admitted Aug 15 1912 Ward 03.



Kelly (11) is of this opinion, and the experiments of Menge and Kronig, who introduced streptococci and staphylococci into the vaginas of pregnant women, showing that in twenty-four hours vaginal cultures were sterile, is evidence that the vaginas, at least of pregnant women, are quite resistant to infection. Pollack has shown that with other infections of the vaginal mucosa, especially gonorrhœal, the vaginal mucosa loses much of its power of resistance, and pyogenic and intestinal organisms are usually present.

In the case I report, however, there was no evidence or history of any such previous infection.

Koch believed that the route of infection in his case was by the organisms wandering through the gut into the abdominal cavity, and then finding their way into the tube. I doubt whether such an infection would be possible except with a perforation, which was not present in any of the cases reported, for had the wandering organisms been but few in number, the leucocytes would have taken care of them, and if the number of organisms were great other intestinal organisms would have accompanied them and a peritonitis resulted. Dirmoser is of the opinion that in his case the organisms wandered out of the large gut into the lymph spaces, then into the surrounding connective tissue, finally finding their way into tube and ovary. He admits the possibility of its being a hæmatogenous infection, but does not consider it so probable.

These theories, along with the possible penetration of the rectum or bladder by the organisms, with ultimate location in the tubes and ovaries, are practically, theoretically, and atomically so much more complex and improbable that, carefully considering all probabilities, I am very much in favor of the view that my case, at least, was hæmatogenous in origin.

Stone (13) has seen numerous cases of secondary tuberculous infections, but does not say what the primary infections were, though he states that he does not believe the primary infection invited the secondary infection, a statement in which I cannot agree with him. However, considering the advanced and extensive state of the tuberculous infection seen microscopically, one can scarcely doubt that the tuberculous pelvic condition, in my case, preceded the typhoid infection. Weight is given this supposition by the fact that the patient had a pulmonary tuberculosis, which was very likely primary to the tuberculous condition in the pelvis.

It is quite probable that the pelvic tuberculous condition was accentuated and progressed more rapidly with the subsequent typhoid infection, for, as Ravenel (12) points out, tuberculosis of the lungs with cavity formation, which is peculiar to man and the higher apes, is always a mixed infection, and being mixed, progresses more rapidly than in the lower animals which are not highly susceptible to other organisms.

In closing, I might add that, though the number of organisms infecting the female pelvis is fairly extensive, but two cases of infection with so common an agent as B. influenza are reported, one an infected pyohydrosalpinx by Kiskault (14), and a case of puerperal infection with isolation of the influenza bacillus from the uterus, by Thalheimre (15).

CONCLUSIONS

1. That in post-typhoid pelvic abscesses, the B. typhosus probably plays a more important rôle than is suspected.

2. That puerperal infections coincident with or shortly following a typhoid infection may often have the typhoid organism as a causative agent.

3. With these conditions, a careful inquiry into the past history for typhoid infections will probably bring out some interesting results, especially when coupled with a careful bacteriological examination of all pus from pelvic abscesses.

4. That with a previous pelvic infection, which is more or less destructive and lowers the resistance of the parts, one would naturally more often expect to find a secondary infection.

5. That the simplest and most plausible mode of infection is by way of the blood stream.

6. That hexamethylenamin, which has proven so useful in preventing post-typhoid cystitis, cholecystitis, etc., though its excretion by the uterine and tubal epithelium has not yet been proven, may here be found to be of advantage, at least in the prevention of such a post-typhoid complication.

I wish to thank Dr. Hunter Robb for his kindness in permitting me to report this case, as it was in his service in the Lakeside Hospital that the case occurred.

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HOW CAN WE IMPROVE THE RESULTS OF OUR OPERATIONS FOR CANCER?[1]

By TRUMAN ABBE, A. B., M. D., Washington, D. C.

IN looking over the mortality records of the census area of the United States, one finds, alarmingly near the head of the list, a condition that is all too well appreciated by the surgeon, namely, cancer. The death rate per hundred thousand inhabitants has increased from 64 in 1900 to 69 in 1905 and 76 in 1910. In the state of Massachusetts, where we have figures extending over a longer period, the cancer death rate doubled between 1850 and 1875, and since then has nearly doubled again.

We all recognize cancer as primarily a surgical condition, surely curable by wise eradication in its early stages. And yet when we look at the results of our treatment of cancer they are most disheartening. Of the breast cancers coming to the surgeon nearly a quarter are already inoperable and at least one half of those operated on eventually die of recurrence. Even in the most favorable cases, seen in the first six months and before the cancer invades the axilla, the reports of our large clinics show that one in five dies of the cancer. In cancer of the uterus when clinical symptoms appear it is already very likely to be too late for eradication of the condition. From forty to eighty per cent are conceded to be already inoperable, and of those operated on in the favorable cases possibly one in four lives more than five years. Sampson says that in half of the cases operated on, the cancer has already extended beyond the uterus, and what is called recurrence is truly but a continuation of the growth. In the cancers of the stomach and intestines (which make up nearly one half of all the cancers) two thirds are inoperable when the diagnosis is made, and even then at the Mayo clinic nearly two thirds of those operated on have to be contented with hopeless exploration or a palliative operation. Even of those radically operated on, not much more than three per cent live beyond five years. Such reports surely justify and emphasize the importance of the consideration of means to improve the results of our cancer operations.

The first question that arises is whether we have any other satisfactory line of treatment. The last six months have brought out several suggestions for constitutional treatment that offer some hope. In Germany, Wassermann tells of experimental work on mice with an eosin-selenium compound which, injected into the blood, has a selective action on cancer cells, killing them. He has published no results of work on man. In Rome, Fischera has started work on an autolysate from human fœtuses, which he has injected with apparent cures in twenty-five per cent of his eighteen inoperable cases. In New York, Berkeley and Beebe are trying a vaccine from the serum of mammals into which they have injected human cancer, and they report marked benefit. But all this work is too new to be relied on at present, as our previous experiences in these lines have proven unsatisfactory; so that the *local eradication* of this disease must still be given first choice in the line of treatment.

For the local eradication of the cancer certainly the knife is the most serviceable instrument. In certain cases of cancer of the cervix and in some skin cancers, *cautery*, either actual or chemical, *and radiotherapy have a very distinct usefulness*. In some apparently hopeless cases of cancer of the cervix the cautery does what seems a miracle. And in skin cancers, especially about the face, radiotherapy is undoubtedly taking the place of the knife. In fact, the Röntgen ray has demonstrated its usefulness to such an extent that it is being adopted more and more after all cancer operations. Such a use of radiotherapy, done with circumspection, undoubtedly will prevent recurrences in some patients and prolong life of more, thus improving our operative results.

The surgeon himself, however, can greatly

[1] Read before the Washington Surgical Society, May 17, 1912. (See discussion, p. 227.)

help the results of the operative treatment. First, in the *careful selection of the cases* suitable for operation. Confidence instead of doubt can be won for the surgical treatment of our cases by the painstaking diagnosis of inoperable conditions before starting the operation. In the breast cases, the presence of distant metastases, especially in the mediastinum, the involvement of supraclavicular lymph nodes or the chest wall all exclude operative cures. In the uterine cases the involvement of vaginal wall, bladder, or rectum, or the iliac glands, practically excludes cures. In the stomach cases, Boas says that the clinical symptoms are never present in the stage adapted to operative cure. Certainly the involvement of the supraclavicular node, the umbilicus, the rectum, and the ovaries, all of which he frequently finds, excludes any operative cure. He calls special attention to the danger of finding the metastatic mass present in twenty to thirty per cent of gastro-intestinal cancers in its usual seat in the rectum, on the anterior wall two to four centimeters above the prostate, not ulcerated, and not growing from the mucosa, and thinking that mass the primary growth, though primary rectal growths almost always start from the mucosa and show ulceration. He speaks also of venous thromboses in the legs as showing the existence of cancer in the blood. He would have us sift out all these inoperable cases by very careful examination before making even an exploratory laparotomy, and save the discomfort of finding the condition inoperable after starting the operation. If we can sift out the incurable cases and tell the patient or his friends the impossibility of cure without operating, and that we can do only a palliative operation, we gain the confidence of the laity in place of their distrust of our ability and show them the importance of seeking help early, instead of having the people blame the surgeon for inadequate work. Mayo says, "If cancer surgery is in disrepute, it is because too large a proportion of patients is accepted for operation without explanation, at a stage when there is no possibility of cure and when the patients or their families should have been informed of the hopeless condition. If left without operation they would have been living examples of ill-advised delay instead of the unsatisfactory results of ill-advised surgery."

Second, we all appreciate the importance of doing *radical early operations*, removing the near lymph nodes, with the tumor, by *block dissection*, even before the lymph nodes show gross signs of involvement. And yet how often we see incomplete operations, not merely incomplete in not removing nodes but in doing too limited a local operation. Some of us are too likely to think of wound closure before cancer eradication. We all have had to do over cancer operations for local recurrence after a primary operation, by ourselves as well as by others, and yet we still at times try to persuade ourselves that in this particular case a less extensive operation will suffice; that in this cervix case we need not clear out all the loose pelvic tissue along the iliac vessels; that in this breast case, with a mass only the size of a hazel nut adherent to the skin, we need not clear out all the axilla and the deep pectoral fascia; that in this lip case we can wait a little longer until there is something palpable under the chin or in the neck before we do a radical operation. And yet we know that we should do the extreme operation at the outset. Warner's figures from the Heidelberg Cancer Institute show that seventy per cent of all cancer recurrences are local — from incomplete operations. To be sure a very large number of our cancer operations are done at a stage when thorough removal is not possible. But when we do get the opportunity we certainly ought not to let it slip from us in the vain hope that the tumor mass embraces all vestiges of the cancer. To what extent we must be radical will always remain to be decided for each case on its merits by the judgment of that surgeon.

The danger of the limited operation has been brought out forcibly by Paine and Nicholson, who showed by experimental surgery on mice that incomplete removal of the cancer caused early recrudesence in twenty-three per cent of the cases and that this recrudesence was much more virulent than before the operation, developing at a rate two or three times as fast as the similar growths

in control animals. So that if we do not do a complete primary removal it is questionable whether any operation should be done, for we must bear in mind the chances of hastening the patient's end.

Third, in the *technique of operation* the surgeon has one or two points to consider. Coffey has noted in breast operations, during the period when the operation was done from the chest towards the axilla, that recurrences appeared in the axilla, and that now, with the type of operation starting at the axilla and working towards the chest wall, the recurrences appear in the chest wall. This he attributes to the manipulations of the cancer tissue during the operation, squeezing out the cancer elements into the wound. If this is the true explanation, then there is also a squeezing of the cancer elements through the tissues by tumor manipulation without cutting, and the least possible manipulation of the cancer area before the mass is out of the body the better. This would argue in favor of the minimum examination of the patient compatible with efficient diagnosis, and the preparation of the operative field with the least possible mechanical disturbance of the tissues; for example, the painting of the skin with iodine would be preferable to the soap and water scrubbing followed by the bichloride washing. For the same reason, during the operation the manipulation of the tumor should be as limited as possible.

Again we note the frequency of stitch-hole recurrences. We can avoid many of the stitch holes by using adhesive plaster strapping to close the wound, notably in the breast and lip cases.

So much for the work of the surgeon; but before the case comes to his hands the fate of the patient has often been determined. To get the best results from our surgery *we must get the cases in the early stages*. In some cases the patient, through ignorance or fear, refuses operation in the opportune moment of the early stage; and considering the proportion of post-operative recurrences which we acknowledge, the view of the layman is perhaps justified. But in the case where the diagnosis is made early, the layman should have quoted to him the results, not of all cases, but of the early cases in the hopeful condition, with eighty per cent or more of cures; and when those results are instilled into the popular mind the layman will not be so likely to procrastinate. There are a certain number of cases where the family physician attempts treatment of various lines before consulting the surgeon and so delays radical treatment until too late. And that result can be remedied only by education of the physician, preferably while he is a student in the medical school, but also later, through our journals, until he appreciates that thorough early eradication is the only acceptable cure for cancer.

But still more important is the question on which we all need education: that of how to make an early diagnosis of cancer. The statement of Boas, that when a patient has clinical symptoms on which we are justified in making a diagnosis of cancer of the gastro-intestinal tract, he is already beyond hope of operative cure, and that of Otto that, of one hundred and ninety-six cases of cancer of the stomach and intestines, one hundred and twenty-one died within six months of the first symptom — these statements show how inadequate the best of us are to make an early diagnosis of cancers that we cannot see or feel. We are having brought out many new tests for cancer, all still in the experimental stage but offering some hope of diagnosis. Some are based on serum reactions, some on special ferment productions, some on urine changes. The Röntgenographic study of the suspicious cases also helps in the diagnosis. Perhaps these tests will eventually lead to a diagnosis of the intestinal cancers at a curable stage.

In the cancers of the breast and uterus, while it is also true that the condition develops in many instances without clinical symptoms till beyond the curable stage, yet it is within the power of the surgeon to make a diagnosis if he examines the patient in the early stage. To make these diagnoses *we should get all women of the cancer age to return for routine examination of breast and uterus every six months*, just as most of the educated classes now go to the dentist for routine semi-annual examination of the teeth, not waiting

for symptoms to drive them to seek aid. With the teeth, the penalty is a toothache. With the breasts and uterus, the examination is more distasteful to the patient; but the stake is not the fleeting toothache with at most the cost of a tooth extraction, but months of distress and horrors, and in the end, life itself. The women will permit and even request the examination if the physicians will do their part and show them the importance. We feel that it should be the duty of every accoucheur to get each of his patients to return every six months for examination of breasts and uterus. Many of his patients do come back to him for one thing and another fully that often and his suggestion of an examination would be welcomed without question. If he finds no cancer the woman is happy. If he finds the cancer it is much more likely to be in a comparatively early stage and cure reasonably hopeful. That the examination of the parous woman would not reach all the breast and uterus cancers is obvious. Theilhaber found twenty-seven per cent of three hundred and forty-seven cases of uterine cancer in nullipara. Paus found thirty-one per cent of breast cancers in nullipara. We would do better than the accoucheur if we got all women over thirty-five years of age to present themselves for routine semiannual examination of breasts and uterus. But the medical profession must win even greater respect than it now holds from the laity before the virgin of thirty-five years, without pelvic symptoms, submits to vaginal examination. For that respect we must work.

The most hopeful line of improvement in our cancer treatment, however, is in *prophylaxis*. From the study of the cancers of which we can get a history from their incipiency we appreciate that certain factors lead to the development of cancer—persistent irritation, physical or chemical. The chronic inflammation, chronic ulcer, scar, wart, mole, irritant secretion, hidden blood clot following trauma, colloid collections as in the thyroid, fibroid tumor, or for that matter benign tumor of any type, gallstone, kidney stone, the physiological changes of involution in uterus or breast, the Röntgen rays, the sunshine, keratoses in the skin from age or drugs, all are followed fairly frequently by cancer. Hence we must educate the layman to avoid continued irritation of all kinds.

Wilson and Willis at the Mayo Clinic showed that in a very large proportion of the cases, cancer could be traced back to displaced cells which showed a tendency to revert to the embryonic type. Such displaced cells are to be seen in the chronic ulcers of the mouth and stomach, in the obliterating appendix, in the diverticula of the intestines, all of which should be removed if they cannot be promptly cured. They found evidences of previous isolation of epithelial cells in three per cent of the rectal cancers, ten per cent of cancers of the cæcum, thirty per cent of those of the lip, thirty-three per cent of those of the gall-bladder, forty per cent of those of the colon, sixty-seven per cent of cancers of the stomach, and one hundred per cent of those of the appendix. The regression of the uterus and breasts gives the same conditions; the inflammatory processes in the prostate do the same. The hypernephroma is a group of prenatal isolated cells. All these show the same tendency of isolated groups of epithelial cells to run amuck. If we appreciate these conditions as leading frequently to cancer, then we will treat these primary conditions more carefully, and if necessary eradicate them by excision or some other means before they become cancerous. Bloodgood states that of the pigmented moles which have undergone cancerous degeneration and then been operated on he has seen sixty-five cases, and not one has had a permanent cure. Yet how easy it would have been to remove the pigmented mole before its degeneration. And certainly if a mole starts to degenerate its immediate eradication is imperative.

As precancerous conditions in the cervix uteri, may be considered the unhealed lacerations that are bathed in an irritating secretion. If these lacerations are kept clean and unirritated certainly some of the cancers would be avoided. On the penis, the tight foreskin, with its retained secretion, is very frequently evident as a precancerous condition. In the stomach, any ulcer that does not heal promptly under medical treatment should be removed rather than allowed to drift on until

the evidence of cancer development is obvious and the prognosis hopeless.

As to the effect of trauma, Theilhaber found one hundred and forty-eight cases of carcinoma and three hundred and twenty-four cases of sarcoma that followed an injury. More than half of the sarcoma cases developed within six months from the injury. Practically all of the carcinomata were in the breast, while many of the sarcomata were in the extremities. Hence we are warned to watch the traumata and tell the patient to do the same and report if the bump does not promptly go away.

The laity must be educated to feel that cancer is preventable and also curable if treated radically and early; that the diagnosis must come from the physician and not be delayed until it is evident to the patient. The work that has been done in education on the subject of cancer in Germany, started by Dr. Winter and adopted by a number of medical societies in that country, has spread through ten other European nations and to parts of the United States. Winter assures us that the fear lest the patient and the public become overanxious in dread of cancer is groundless, as the physician's advice is complete assurance. Our tuberculosis work shows similarly that the dread of a disease is not increased by judicious education. Winter has planned an educational campaign covering the training of the medical student, postgraduate courses in cancer diagnosis and treatment, medical press notices (especially insisting on the results of cases where the early diagnosis was overlooked), health authority publications of leaflets for physicians and midwives, prosecution of all persons treating cancer who are not qualified physicians, and education of the public to the idea that cancer is curable. New York city has adopted a leaflet, "What every woman should know to prevent death from cancer of the uterus." The effects of this educational campaign are already being felt in Europe, where the operative statistics show an increasing proportion of operable cases coming for diagnosis and treatment, and therefore higher percentages of permanent cures.

SUMMARY

We all recognize that our cancer operations are too late, too limited, and often on too local a diagnosis, and that the people have the well-founded idea that our cancer operations in general are unsatisfactory and do not cure.

To get better results we must enforce certain well-established conceptions: that early eradication is at present the only reliable method of treating cancer, and operation in general the most satisfactory method of eradication, though energetic caustics and radiotherapy have their distinct fields. That painstaking diagnosis to select the cases suitable for curative operations, complete eradication at the primary operation, with the minimum manipulation, will allow fewer recurrences.

To get earlier cases for operation we must educate the medical student in the medical school to appreciate the importance of early diagnosis and prompt radical treatment. We must educate the practitioners through the medical journals to the prevalence of cancer, so that their eyes will be open to seek an early diagnosis in cases with the slightest suspicion of cancer, or even in the prolonged troubles of many types that have not yet raised the suspicion of cancer. And we must educate the women to seek routine semiannual examinations of breasts and uterus at the hands of their accoucheurs.

To get our best results we must educate the layman to avoid persistent irritation, and the physician to keep constantly in mind the precancerous conditions and treat them so efficiently that the observable cancers never develop.

A POSSIBLE FACTOR IN THE CAUSATION OF CANCER

Munity and Immunity. Demineralized Food. A Cancer Parasite

By HORACE PACKARD, M. D., Boston
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THE following theories and conclusions are the result of many years observation and study of tumor growth, both in the vegetable and animal worlds.

Laboratory investigation and experimentation have signally failed to throw much light upon the nature, causation, or mode of transmission of malignant disease. We are practically as helpless to-day in the treatment of cancer as were our foretathers of one hundred years ago; and we are face to face with the momentous fact that malignant disease is increasing at an appalling ratio.

The United States census of 1910 announced for that year 75,000 deaths from cancer, an increase of 8,000 over 1908, a rate of increase of 4,000 a year. At the present writing there are about 225,000 cases of cancer in the United States of America.

In New York State there have been 8,000 deaths from cancer in the past year. Singularly the lowest mortality rate is in the maritime districts—78 to the 100,000—while in the western districts it reaches 108 to 100,000. There were 3,000 deaths from cancer in 1891 and in 1911 there were 8,000. In the later years there has been an increase of 500 a year, which is much greater than in the earlier years.

BRIEF CONSIDERATIONS OF CERTAIN WELL-KNOWN FACTS

1. Cancer is a disease of civilized life, and, for some reason not yet understood, it is more prevalent among the well-to-do and wealthy portion of the population.

2. Primitive people do not have cancer, or to so slight a degree that it is a negligible quantity. As far as known the American Indian, prior to the advent of the white man and civilizing influences, did not have cancer. The Eskimo still lives as he has for countless generations, uninfluenced by modern life—he is practically cancer free.

All races and tribes, upon whatsoever part of the earth's surface, who live a simple life, subsisting upon the natural products of the soil, whether of vegetable or animal origin, unmodified by civilized methods of manufacture or cooking, are practically cancer free.

3. All efforts to graft cancer from a cancer patient to another individual or to lower animals have failed, although autografting, i. e. grafting from one part of the patient's body to another, is easily and successfully accomplished; therefore it may be stated that animal tissues in a normal state are immune to cancer.

Experimental grafting of cancer from one human being to another is hedged about with such strenuous ethical objections that really no reliable knowledge exists upon the subject, except that such desultory tests as have been made are all negative. Moreover, surgeons, physicians, and nurses, who in the ordinary routine of their work deal frequently and over long periods of time with cancer disease and cancer discharges, so rarely develop cancer in their own bodies that a predominating vigorous immunity must be accepted.

4. Approximately averaged, one tenth of one per cent of civilized people have cancer. For some reason as yet unknown, their resistance to cancer disease is lacking or has been lost.

5. There is some evidence that a small percentage of apparently hopeless cases of cancer, in some as yet unknown way, regain sufficient resistance to subdue the disease and recover.

The lower animals in a wild state do not have cancer, or so rarely that it is a negligible quantity and has largely escaped observation. On the other hand, animals long in captivity not infrequently develop cancer, and in domesticated animals cancer is an occasional occurrence.

The artificial propagation of trout has long been an established industry. A matter of much concern among trout breeders is the fact that such artificially bred trout develop a tumor which threatens to seriously cripple the industry.

THEORY

Theories are of scientific value only when they lead to or coincide with known or demonstrated facts.

The writer's conclusions, as hereafter set forth, are based upon the theory that all forms of malignant disease are possible only because of absence of or loss of immunity, and the invasion of the susceptible organism by some as yet unknown parasite.

SPONTANEOUS RECOVERY FROM SEEMINGLY HOPELESS CANCER DISEASE

Until very recently, such an attitude of forlorn despair has existed in the minds of the medical profession regarding cancer, that anyone reporting a case of recovery from what had seemed a hopeless and inoperable condition was looked upon as a fool or a knave and the case relegated to the "error in diagnosis" class.

About six years ago the writer made an effort to gather statistics of unanticipated recoveries in cancer cases which had seemed hopeless. The following are brief reports of them:

CASE 1. Patient of Dr. J. J. Buchanan. St. Mary's Hospital, Pittsburgh, Pennsylvania. Sarcoma of the thyroid, pressure stenosis of trachea, tracheotomy, microscopical examination verified diagnosis. Case considered hopeless and sent home to die. Returned a year later still wearing tracheotomy tube, tumor mass smaller. Two years later the growth had entirely disappeared. Four years after the tracheotomy she died of acute pneumonia.

CASE 2. Patient of Dr. W. F. Waugh. Recurrent carcinoma of mammary gland, dark, hard, red masses in the cicatrix at several places, accompanied by lancinating pain. Patient was seen by several other prominent physicians, who all agreed that it was a case of recurrent carcinoma of the cicatrix. She already presented the characteristic cancer cachexia and was rapidly losing strength. As a temporizing measure and with the hope of relieving pain the Faradic current was applied. Soon after this the characteristic nodes began to subside, pain ceased and the cachectic appearance gave way to a healthy color of the complexion. Five years later she was still in good health with no local or general indications of cancer.

CASE 3. Patient of Dr. E. L. Larkins. Carcinoma of cervix, foul discharge, bleeding, uterus fixed, patient anæmic, curettement of diseased tissue, diagnosis confirmed by microscopic examination. Six months after there were no physical local indications of disease and the general appearance of perfect health. The only after treatment was bi-weekly local treatment with ichthyol tampons.

CASE 4. Patient of Dr. W. H. Freeman. Case of cancer of uterus, copious, offensive dark discharge, cervix eroded, uterus fixed and surrounded by exudate which filled the pelvis, cachectic, bedridden. Consultation with two surgeons resulted in diagnosis of inoperable cancer in last stage and prognosis of death within a very brief period. Microscopical examination of pieces of tissue from cervix yielded diagnosis of epithelioma. Much to Dr. Freeman's surprise, marked amelioration of symptoms followed and steadily continued until at the end of two years both subjective and objective symptoms had disappeared. At the end of four years the condition of the pelvic organs, on careful examination, seemed normal and the patient's general condition indicated the best of health.

CASE 5. Reported by Dr. E. R. Ahlman. Recurrent carcinoma of mammary gland. Some fifteen years ago one Mrs. F. v. C. was operated upon by Professor Yalmar von Bonsdorff in Finland, Helsingfor, for breast cancer. About a year later she returned to him with extensive cancerous growths involving the scar tissue and the surrounding thoracic wall, giving a picture of *cancer en cuirasse*. He declined to operate again, considering the case hopeless. She then went to specialists in London and Paris, who likewise refused to operate. At that time she was very weak and run down showing signs of far developed cachexia. Case was given up as hopeless. Resigned to the apparently inevitable, the patient turned to the Church for consolation and preparation for death. There came, about this time, a turn for the better, the general condition improved, the recurrent nodes shrank away, and finally full recovery followed. No treatment during this time.

CASE 6. Patient of Dr. Walter Wesselhoeft. Large, nodular, flattened tumor in the epigastrium reaching from under the xyphoid cartilage nearly to the umbilicus. Very tender to pressure, caused nausea and faintness, great debility, emaciation, and distress after food, very feeble and wasted. Consultation with Dr. F. C. Shattuck of Boston resulted in the agreement that all signs were those of cancer of the stomach and that the prognosis was most unfavorable. In the succeeding months it was distinctly apparent that the tumor was diminishing in size and less tender, and that there was a corresponding improvement in general condition. Change for the better, steadily progressed, stomach received food without embarrassment, color returned, gain in weight, strength returned. At end of three months was able

to be up and about all day and enjoy life with the exception of occasional attacks of facial neuralgia.

CASE 7. Patient of Dr. F. S. Smith. Case of recurrent tumor of the right axillary region, twice operated on. Expert opinion was now sought with the advice that the tumor was malignant and amputation at the shoulder joint was necessary. The patient was unprepared for such an ordeal and begged for time to get his home affairs in shape. At this time the tumor was about the size of the fist, the patient was anæmic, had night sweats, and was generally debilitated. In the period of waiting he was placed upon a homœopathic drug treatment and rigid regulation of diet. Much to the surprise of all concerned the tumor began to abate, strength returned, night sweats disappeared, albuminuria which had been observed ceased, and his general health became normal. The tumor finally disappeared, nothing being left but a cicatrix-like ridge about the size of a goose quill.

CASE 8. Patient of Dr. C. M. Boger. Recurrent left mammary tumor, breast removed, recurrence in the scar, development of a bunch in other breast followed by axillary gland involvement. In the succeeding five years Dr. Boger was in close touch with the case and the only treatment was homœopathic medication. The tumors gradually disappeared; symptoms ceased with return to perfect health.

CASE 9. Patient of Dr. W. S. Simpson. Bunch in right breast size of egg, sharp, shooting, burning pains. In preceding two years had been twice treated with caustic pastes. Had recently consulted three physicians in good standing, all of whom advised operation but gave no encouragement as to permanent cure. From about September, 1901, gradual improvement occurred, pain diminished, the tumor receded and finally disappeared entirely. Seven years later the patient reported the breast soft, pliable, not at all tender, as normal as any breast; scar from burning by caustic pastes remaining. The only treatment this patient received was homœopathic medication.

Gaylord of Buffalo, N. Y., and MacKay of England have also collected lists of more or less complete spontaneous recoveries of cancer cases.

MUNITY AND IMMUNITY

Immunity of animal life to malignant disease is evidently a very strongly implanted trait, for nearly all efforts to transplant or graft from one human being to another or from man to animal or vice versa have failed, but a significant fact which has not received due weight is that *autografting has not failed.*

This phenomenon follows the theory of a parasitic cause and loss of immunity just as it should be expected to follow.

It has been and is now a very widely accepted impression among the laity that operation for cancer often results in a rapid dissemination and development in adjacent parts. The medical profession blindly combated this idea, even though over and over again the surgeon saw new nodes of cancer develop along the operation wound and in stitch hole scars. There is at the present time a tacit agreement in the medical profession that operative wounds which open into cancer tissues are likely to spread the disease and implant it in adjacent freshly wounded healthy tissue. So apparent has this become that the modern operative technique for mammary carcinoma, as well as all other forms of cancer, embraces the widest possible dissection, far from the margin of the cancer growth, and removal of the whole mass with all adjacent glands without cutting into or mutilating the diseased growth itself, lest elements of the disease become disseminated.

Since recognition of this fact of autotransplantation, and the shaping of operative technique accordingly, a greatly diminished percentage of early recurrence has been recorded.

Autotransplantation has been experimentally made by Hahn, who engrafted bits of cancer tissue from a mammary carcinoma to the skin of the arms and legs of the same patient. Carmiel reported two similar successes at autografting. Several cases of incidental autotransplantation are on record.

Cripps reported a case of mammary carcinoma where the patient kept the arm bent and in contact with the cancer surface for several months. The skin of the arm near the elbow became the seat of a cancerous ulcer several inches in diameter.

A similar case of autotransplantation is reported by Morgan Williams, where contact infection occurred of an epithelioma of the inner side of the thigh to a corresponding point on the other leg.

Spread of cancer from one lip of the vulva to the other, one lip of the mouth to the other, one eyelid to the other, one vocal cord to the other, and from the tongue to adjacent parts of the cheek, have been observed. Tapping for ascites due to cancer has been followed by the development of cancer in the puncture

Fig. 1. Rhodites radium. Amphilolips confluentus. Andricus punctatus. Trypeta solidaginis. Examples of vegetable tumors caused in every instance by the deposit upon and among the vegetable cells of an insect ovum. From photos by Miss Cora H. Clark, Boston.

wound, suggesting an infecting agent in the ascitic fluid.

Schimelbach reported a case of epithelioma of the ear. The patient was in the habit of handling it. In this way he apparently transmitted it to his lip. Kaufmann reported a case of epithelioma of the hand. This was apparently transmitted to the eyelid by rubbing with diseased hand.

THE RÔLE OF EARTH MINERALS AND SALTS IN BOTH PLANT AND ANIMAL LIFE

Plant roots appear to have the power of selecting from the soil those chemical ingredients which are necessary for their highest development, and elaborating them and storing them away for growth and future generation.

There is a vast impassable chasm between the vegetable and animal worlds, in that vegetables can select and assimilate such inorganic salts and minerals of the soil as their needs best require, while animals must be largely dependent for their food salts upon those which nature throws in their way through the medium of natural or cultivated food plants and wild or domesticated food animals.

What particularly concerns us is, however, what influence upon a plant's resistance to

Fig. 2. Arceuthobium pusillum (witches' broom). A greatly exaggerated growth on a spruce tree due to parasitic infection by the dwarf mistletoe.

Fig. 3. Carcinoma quercus rubræ. A tree cancer found in great abundance among the red oak trees of Cape Cod. Caused by the bacillus phyto-phymato.

parasites results from a deficiency of earth salts in the soil? A few years ago the writer happened upon this fact. In a secluded valley in the state of Maine it came to light that apples grown upon the soil of old stony pasture land reached maturity in a much more perfect condition and freer from worms and insect pests and parasites than those grown in other parts of New England upon land which had been under long cultivation. The reason for this did not appear until later. Those old and neglected pasture lands were full of glacial boulders and deposits, and had never been cultivated because so rocky and supposedly barren. Decomposition of the glacial rocks had been going on for centuries through the process of weathering, with the result that the soil was rich in earth salts and minerals (potassium, silica, manganese, calcium, sodium, and iron).

Further study taught that in areas of the country long cultivated and overrun with plant pests and insect parasites, liberal fertilization of the soil with earth salts (potash, phosphorus, silica, manganese, calcium, and iron) augmented the quality and quantity of plant growth and fruitage, and diminished the ravages of parasites and insect pests.

Further research disclosed the following facts:

1. Food cereals, notably wheat, grown upon the long-cultivated and worn-out grain fields of central Europe yield a product so deficient in earth salts that millers find difficulty in milling it without adding a certain proportion of the grain rich in minerals from the wheat fields of the western portion of America.

2. The demands of civilization are for wheat flour manufactured in such a way that it will make bread which is white in color. Little or no thought has been given to the fact that the intricate process of milling takes away from the product those food salts of potassium, sodium, silica, phosphorus, lime, manganese, etc., which are absolutely necessary for strong, healthy, virile, disease-resisting animal life.

3. Along the whole line of vegetable and animal food products, man is on the losing side in the matter of food salts. In all modern methods of agriculture and dairying, fertiliz-

ing material rich in nitrogen but poor in earth salts is fed to plants. Dairy animals are fed upon the products of such soil and get in turn food rich in nitrogen and poor in mineral salts. The milk from these dairy animals is again rich in nitrogen but poor in food salts. The redeeming feature in the food material of domestic animals is that they receive largely the flour mill waste products (bran, shorts, and middlings) rich in earth salts, and so these may in this roundabout way finally reach the human family.

4. Commonly used methods of cooking are wantonly wasteful of these precious salts. Potatoes probably constitute the most widely used article of diet rich in food salts, next to wheat.[1] The prevailing method of cooking potatoes is to remove the skin, soak them in cold water for a varying length of time, and then boil until "done."

With removal of the outer skin a considerable portion of the inner skin is also removed and both thrown away. These portions are the richest parts of the potato in food salts. The subsequent soaking and cooking dissolves a part of what remains, and about one half of these precious salts are thus lost.

Rice, next to wheat, is the most widely used cereal food. In the milling process or polishing which prepares it for market all or nearly all the pericarp is removed. This is the part bearing mainly the food salts. Both human beings and animals languish and die upon a diet of polished rice.

Animal existence would be impossible without earth salts. Lime and potash in the bones and teeth, phosphorus in the nerves, iron, sodium, manganese, and potassium in the blood and muscles, are universal and ever essential elements present in healthy animals.

It must further be accepted that, incident to the cellular activity of all organic life in the death of old cells and the creation of new, there must be an unceasing excretion of these organic salts and adequate renewal supply must be available in the daily food. Upon this urinalysis is positive in the constant showing of salts of all the mineral elements of body tissue.

[1] Bulletin No. 43, U. S. Dept. of Agriculture.

The modus operandi of these tissue salts is little understood but that they must be supplied for the upbuilding of animal structure, in growth and maintenance of strength, vitality, and health in mature years is beyond argument.

It is a significant fact and one not to be lightly overlooked that cancer takes its rise in epithelial and connective tissue only. In simple terms epithelial and connective tissue cells are the only elements in the animal body susceptible to cancer. What conditions of nutrition or metabolism maintain through one period of an animal's life immunity to cancer, and in another period of its life fail in immunization? Why do the skin cells of the sides of the face, the forehead, eyelids, nose and lips, of aged persons become the frequent site of epithelioma? May it not well be that in the debility of old age they fail to receive those elements or that element of nutrition which makes for epithelial cell vigor and resistance to cancer disease. It is the writer's thought that some one of the food salts commonly found in the food substances of animal life is the life giver and preserver in health and normal formation of epithelial and connective tissue cells. Which it may be of the ten or twelve salts and minerals commonly found in the animal body, we cannot say. It may be something in infinitesimal quantity which has so far wholly escaped our observation.

FACTS IN SUPPORT OF THE PARASITE THEORY OF CANCER [1]

The vegetable world teems with examples of tumor formations, and in nearly every instance a known parasite is the recognized cause.[2] See Figs. 1, 2, 3, 4 and 5.

The writer's thoughts were first turned to a consideration of a possible analogy between vegetable tumors and animal tumors by the chance observation during a holiday ramble that the red oak trees of the Plymouth

[1] The term cancer is used in this paper in its broadest sense, including all forms of carcinoma and sarcoma.

[2] Since these cancer studies were begun some very valuable and convincing work has been done in plant tumors by Dr. Erwin T. Smith, pathologist in charge of the Laboratory of Plant Pathology of the U. S. Department of Agriculture, Washington. See Crown Gall of Plants. Its Cause and Remedy, Bulletin 213; On Some Resemblances of Crown Gall to Cancer, Science, Feb. 2, 1912. The Structure and Development of Crown Gall: A Plant Cancer, Bulletin 255.

Fig. 4.

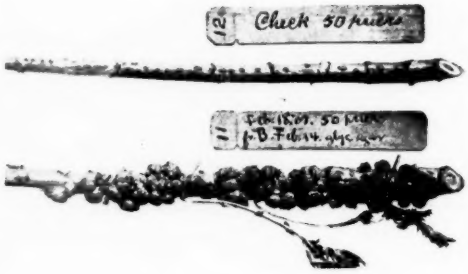

Fig. 5.

Figs. 4 and 5. Examples of a vegetable tumor of bacterial origin found upon the daisy (bacterium tumefaciens.) All these were artificially produced by inoculating with pure cultures. Fig. 5 shows fifty needle stabs on two different stems, one with a sterile needle and the other with a needle dipped in a pure culture of bacterium tumefaciens. Smith, Crown Galls of Plants. U. S. Bureau of Plant Industry, Bulletin 213.

(Massachusetts) forests (see Fig. 3) are infested by a tumor growth, analogous in general appearance, growth, metastasis, and fatality, to cancer growths of the animal world.

Later, and on traveling further afield, an added stimulus to a study of this seeming analogy was afforded by the parasitic tumors found upon the lodgepole pine trees of the Yellowstone Park.

In northern New England the spruce tree is the host for a vegetable parasite (see Fig. 2), the Arceuthobium,[1] which causes great localized broom-shaped overgrowths (witches' broom) that finally kill the tree. A characteristic feature is great overgrowth of the part or branch locally infected.

In northern Maine the spotted alder is a common cone-bearing shrub or tree. While the cones are yet immature, a parasite invades some (not all) of the scales or segments of some of the cones, resulting in elongation and enlargement of the invaded scales to many times their original size.

The ergot of rye and other grains and grasses, produced by the *clabiceps purpuræ*, is another well-known illustration of cell multiplication and overgrowth as a result of parasitic invasion.

In fact, in the vegetable world, there is endless evidence pointing to the stimulating effect of various forms of parasitic invasion upon plant cells and the formation as a direct result of tumors (galls and burls) so similar in their shape, mode of multiplication and sometimes fatal effects, to animal tumors, that one can but be deeply impressed with their analogy. There are plant tumors seen upon every hand, in woodland and along the wayside, and these are in every instance of parasitic origin—an insect deposits an ovum cell amongst the vegetable cells with the result now exhibited.

I would like this thread of thought to run through your minds, viz., that a living potential cell has been planted among living cells of another kind. With the continuation of life of both of these parasitic cells and the host cells, there is an enormous multiplication of the host cells and tumefaction or tumor. The pathological process is identical in both plant life and animal life, and I feel warranted in announcing this influence of a potential cell upon other cells of a different kind as a law of nature; and deductions from observations upon plant pathology (see Figs. 4, 5, and 6) are quite applicable to questions in animal pathology which are hedged about with insurmountable difficulties.

CELL MULTIPLICATION OR HYPERPLASIA A COMMON SEQUENCE OF PARASITIC INVASION OF THE VEGETABLE

The pertinent fact which confronts us as a result of this examination of vegetable parasitism is that in every instance cited there is an enormous local multiplication of cells; in other words, the primary influence of the parasite has been to stimulate the plant cells

[1] Dwarf mistletoe.

Fig. 6. Widespread infection of a group of red oaks in the Cape Cod Forest. Note the clinical similarity to Fig. 7.

Fig. 7. Author's case of multiple melano-sarcoma. Note the clinical similarity to Fig. 6.

to a growth which they never show under normal conditions.

Turning now to the animal world, do we find a known and well-demonstrated analogous state of matters?

At the very outset and in the very beginning of animal life we are confronted by the subtle and profoundly stimulating influence of one cell upon another cell of a different kind. The ovum is but a cell of infinite potentiality. The spermatic cell stimulates it to segmentation and multiplication beyond the contemplation of the human mind.

The blood considered as a tissue exhibits enormous multiplication of its white corpuscles under the stimulus of invasion by pathogenic bacteria.

All inflammatory tumefactions whether of staphylococcus or streptococcus origin may be accepted as analogous examples of cell multiplication as the result of the influence of other cells of a different kind.

Tubercle, gumma, leprosy, and actinomycosis are all universally known examples of tumefaction and cell multiplication from known parasitic causes.

Those tumors of the animal world which are not of known parasitic origin, such as lipomata, chondromata, adenomata, exostoses, carcinomata, and sarcomata, present, in a general way, exactly the same characteristics of cell multiplication as we have seen in the vegetable world and in some tumefactions of animal life.

The benign tumors above enumerated may be dismissed as of insufficient consequence to raise the question of their mode of origin or cause.

Of malignant tumors, however, the question of cause is a burning one and is destined to so continue until answered.

The microscope has thus far failed to show any micro-organism, and laboratory investigation has not yet demonstrated a parasite which the world is ready to accept as the cause of malignant disease.

But, casting all this aside, have we not sufficient facts in the natural history of the disease and in the analogy of tumor growth in plants to tumor growth in animal life, to accept, until such time as further investigation shall positively demonstrate, the working hypothesis that *all malignant growths in animal life are parasitic in their origin.*

Here is a case of human cancer (Fig. 7) the initial lesion of which appeared upon the forehead. The next outcropping of the disease was upon the chest. At the time of her death scarcely any portion of the body was exempt from invasion. In the mind of the writer no theory can so well account for the initial focus of the disease and its subsequent dissemination by the way of the lymphatics as a living virile parasite.

At the present writing, a case is under observation and treatment from whom, in April, 1910, a small cutaneous tumor developing from a birthmark which microscopical analysis showed to be carcinoma, had been removed from the lower part of the anterior portion of the thigh. A few months later a similar tumor appeared in the skin near the groin; next, another growth developed in the periphery of the left mammary gland. Now there are nodes upon the back, under the arm, in the inguinal glands and in or near the cicatrices of early removal, numbering over one hundred.

In May, 1908, a young woman exhibited a movable bunch, superficially located near the lower border of the pectoralis major muscle, near the axilla. Removal and microscopical analysis announced carcinoma. Later other bunches appeared in the cervical region, in the groins, and abdomen, with subsequent extension to adjacent and distant parts.

These painful cases of local incidence of malignant disease, are so familiar to all physicians that reiteration is unnecessary.

WHAT EVIDENCE DO WE POSSESS SHOWING THAT DEPRIVATION OF ADEQUATE SUPPLY OF FOOD SALTS MAY BE A FACTOR IN THE INCREASE OF CANCER AMONG CIVILIZED PEOPLE?

FACTS

1. In the course of natural events upon the earth's surface there is a constant loss of those earthy salts which are essential to vegetable and animal life and health. Every river, stream, and brooklet is emptying them into the sea from which none ever return to the land.

2. The land losses are never replenished except from the slow weathering of the exposed rocks of the earth's crust.

3. The ocean is the great reservoir of the earth salts.

4. As far as is known sea life is free from any disease comparable to the cancer disease of land animals.

5. Sea life appropriates to its fullest needs all or any of the salts of the sea.

6. Those human beings whose environment necessitates subsistence exclusively or almost exclusively upon sea food are cancer free.

7. Primitive people who subsist mainly upon the flesh of wild animals and upon vegetables not at all or but slightly changed by civilized methods of manufacture and cooking, do not have cancer, or if at all in such a slight degree that it is a negligible quantity.

8. People of the lower classes who live upon a very restricted diet, bread, potatoes, and a little meat, all cooked in a primitive way with little or no wasteful loss of salts and juices, suffer less from cancer than the wealthy, whose diet embraces all edible things from all quarters of the globe and prepared according to the ultra refinements of cooking.

9. The most recent word upon the influence of the cereal organic salts comes from the Philippine Islands and the coast of Labrador.[1]

The almost universal method of preparing rice for market is by a process of milling to remove the outer covering or pericarp. The product is known commercially as "polished rice." Nearly all the organic salts are thus removed. Beriberi is a disease of people whose chief diet is polished rice. Change to a diet of unpolished rice prevents and cures the disease.

10. That we may free the human family from cancer by reform in dietary is perhaps too much to hope for, but as physicians and guardians of human health and life, is it not our duty, in the light of present knowledge of their potent influence for health, strength, and vital resistance, to launch a propaganda for reform in the conservation of the food salts in cereal and other vegetable foods? Cereals and potatoes enter more extensively

[1] Practical Experience with Beriberi and Unpolished Rice in the Philippines, by Victor G. Heiser, M. D., Beriberi Caused by Fine White Flour, by John M. Little, M. D., J. Am. M. Ass., June 28, 1912. The Fight to Live in Labrador, by Dr. Wilfred T. Grenfell, Boston Transcript, July, 1912.

into the dietary of civilized peoples than any and all other food articles combined. The demand of the civilized world, in its ignorance, is for bread made from bolted flour—the most important food material bereft of its vitalizing elements; and in its thoughtlessness the higher classes eat of potatoes from which more than one half of the food salts have been removed by refined methods of cooking.

11. The writer begs in closing to ask the co-operation of all physicians to strive for reform in the dietary of all people so far as it relates to the conservation of the food salts. Proof of the truth of the teachings set forth in this paper must be a matter of years. If the public can be convinced that in eating of food which has been robbed of its important life-giving and health maintaining elements they are inviting cancer disease, that greatest of all levers, public sentiment, will bring about reform in methods of manufacture of food materials.

CONCLUDING PROPOSITIONS

In the light of present-day knowledge is the time not now ripe for full acceptance as fact that the active cause of cancer in the human family is some as yet unidentified bacterium, protozoön or fungus?

Is it not a most reasonable assumption that all animal life in a normal state of environment, and supplied with nutriment bearing all the organic ingredients necessary for the upbuilding and maintenance of a healthy resistant vitality, possesses in itself a protective immunity to cancer?

In view of the apparently well-established fact that in the vegetable world an adequate supply of the earth salts (phosphatic, potassic, feric, manganic, silicic, sodic) act as a distinct deterrent upon parasitic life and make for vigorous, virile, disease-resisting, healthy life, may we not assume as much for the animal world?

Since a critical examination of the habits of life of civilized cancer-plagued people, in comparison with the habits of primitive cancer-free people shows that the main difference is in a dietary poor in food salts of the former and a dietary rich in food salts in the latter, is it not the most logical and rational course to adopt this as the keynote to our plan of cancer treatment? It matters not whether the diet consist wholly of animal food or wholly of vegetable food. The Eskimo tribes have existed for centuries upon a dietary of uncooked animal food and are to-day a strong, enduring, cancer-free people. There are lower animals without number which live exclusively on the flesh of other animals and are strong, enduring, virile, and cancer free. There are wild tribes, in the as yet wild places of the earth, whose diet is wholly of vegetable products. These children of the soil are also cancer free. There are lower animals without number which live exclusively upon plant life and are strong, enduring, and cancer free.

It is far from the disposition of the writer to cast any disparagement upon the herculean laboratory work which has been done in seeking for the cause of cancer and searching for a cure. Much of great value has been learned, much more may yet be accomplished; and let us earnestly hope that the long sought for cancer antitoxin or cancer germicide may be discovered.

In the meantime may we not follow the simple teachings of Nature as we see them laid before us in the natural history of cancer disease and instruct the nations of the earth that if their peoples may hope for strong, disease-resisting bodies, bodies possessing a sufficient resistance to combat the frightful, dreaded cancer disease, a well-balanced dietary must be adopted including not only proteids, carbohydrates, and fats, but also *food salts*.

Note.—Since this article was written reports have reached the writer from Drs. Wilfred T. Grenfell and John M. Little, who are engaged in missionary work on the Labrador coast, that the introduction of refined flour and its wide adoption as a staple article of diet by the natives has been followed by many cases of beriberi and that *an increasing number of cases of a cancerous nature have been noticed this spring.*

MECKEL'S DIVERTICULUM AND COMPLICATIONS

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THE presence of a Meckel's diverticulum is of a frequent enough occurrence and its pathology is so fatal that we should always bear it in mind when dealing with abdominal cases. Because of the lack of general knowledge of its presence I thought it would be worth our time to briefly review the embryology, anatomy, pathology, and surgery, and add a few cases to the literature which occurred in my practice.

History: Ruysh in 1701 first called attention to its presence, and Morgagni reported several cases, but John Frederick Meckel was the first to call general attention to it, and to advance a theory as to its origin and its importance as a cause of abdominal affections.

Origin: About the end of the third week of fœtal life the primitive gut communicates with the yolk sac by the vitelline omphalomesenteric duct (yolk stalk). As the abdominal wall closes, this gradually becomes smaller, and normally disappears at about the sixth month. A persistence of this duct is called Meckel's diverticulum, and in its most perfect form consists of a tube similar in structure to the small intestine, and is patent at the umbilicus forming a fæcal fistula. From this perfect form there exists all grades, depending on the completeness of the developmental changes going on in the duct; in some cases consisting of a blind tube hanging free into the abdominal cavity, or attached by a fibrous band to the umbilicus, mesentery, or other abdominal organs. This fibrous band or terminal ligament is the more or less atrophied remains of the omphalomesenteric artery and vein.

Location: It is usually stated to be in the lower one fourth of the ileum, but may be found anywhere in the intestinal tract from the pylorus to the ileo-cæcal valve. This variability can be explained along developmental lines as follows: In the earlier state the intestinal tube can be divided into three parts: the head gut, the mid gut, and the hind gut. The mid gut becomes U-shaped, called umbilical flexure, and at its greatest convexity the vitello-intestinal duct is attached. The upper limb of the umbilical flexure develops into the jejunum and part of the ileum, and from the lower limb the remainder of the ileum, the cæcum, and the ascending colon develop. In the subsequent development a retardation of one or the other limb would cause a variance in the position of the Meckel's diverticulum, as a hindrance to the lower limb would cause the diverticulum to be close to the ileo-cæcal valve; whereas if most of the development occurred in the lower limb then the diverticulum would be located higher up, and be found in the jejunum or even the duodenum. The position on the intestinal loop is usually opposite the mesenteric attachment, but may be found on the side or even arising from between the two layers of mesentery.

Length: The length of the diverticulum varies, as before stated, according to the degree of involution of the omphalomesenteric duct, and may be short and blunt or very long. Lamb, in a series of 109 cases, found the average length to be about two inches.

Form: This is usually like the finger of a glove, but may be constricted at its base or even globular and the communication with the gut closed, forming a cyst. The distal end may be clubbed or divided, or may be open and communicate with the umbilicus.

Structure: Like the bowel, it has its three coats: the mucosa, the muscular, and serous, as well as having the crypts of Lieberkuehn and Peyer's patches.

Meckel's diverticula have been found to be the cause of many cases of intestinal obstruction. Leichterstern found in a series of 1134 of obstruction that 6 per cent were caused by Meckel's diverticulum. Also in the combined reports of Haven, Duchanssoy, and Brinton, in a series of 991 cases 6 per cent were due to Meckel's diverticulum.

The obstruction may be caused in many ways, of which I mention the following:

1. Obstruction from a kinking due to the traction by an attached diverticulum.

2. It may cause a volvulus of the small intestine by twisting the bowel on its long axis at the point of origin of the diverticulum.

3. A chronic inflammation of a diverticulum and adjacent parts may cause a cicatricial narrowing of the lumen of the bowel.

4. An inversion of the diverticulum into the bowel causing a mechanical obstruction, or by being drawn farther into the lumen of the bowel causing an intussusception.

5. A diverticulum which is attached may act as a band around which the bowel becomes twisted, and cause a simple constriction or a volvulus.

6. A prolapse of small intestine through an umbilical fæcal fistula, or a prolapse of a Meckel's diverticulum into a hernia sac.

In reviewing the literature of the cases of Meckel's diverticulum reported, the following facts may be noted: The condition is found in about 2 per cent of the bodies. E. M. Corner of London (1), reports a case in a male child only four weeks old which was patent at the umbilicus, and from which fæces was expelled. It developed an intussusception and died. The average age of the reported cases which were operated was 15 years old. Males predominated.

Symptoms: The symptoms caused by a Meckel's diverticulum vary greatly, depending upon the pathology induced or accompanying it. Comparatively few come to the operating table considering that they are found in 2 per cent of the bodies. Many cause no symptoms, or the disturbance is so slight that it is overlooked. Often they have been mistaken for appendicitis or other diseases, as is shown in the various reports. The pain is usually colicky and intermittent, and located around the umbilicus, either to the right or to the left. It may be accompanied by vomiting, and is followed in a fair percentage of cases by bloody stools. The amount of blood when passed is usually copious and dark. A history of previous attacks is often given. Umbilicus often retracted. Usually no fever is present for the first few days, and the patient's condition is very good considering the severe onset. If any obstruction is present, the usual findings are present, such as tumor, peristaltic waves, vomiting, and constipation.

In "Gray's" case, the condition was good as late as the seventh day. It is often brought on by some more violent exercise. Mayo in a series of 10,600 abdominal operations found a Meckel's diverticulum fifteen times. In ten of these it was removed to avoid later trouble, and in the other five it was the cause of the symptoms for which the patient was brought to the hospital.

A. E. Halstead (2) gives a summary of 69 cases of Meckel's diverticulum with obstruction. Fifty-seven of these were operated with a mortality of 59.1 per cent. The obstruction was caused by some form of a band, causing a constriction. H. Tyrell Gray, London (3), presents a very complete table of forty cases of invagination of Meckel's diverticulum, with various complications. Of those in which the results were mentioned the mortality was about 60 per cent. The high mortality, I believe, is due partly to the fact that the condition is not always recognized early, and in part because the pathology produced by a Meckel's diverticulum is often very extensive, as illustrated by Cases 2 and 4 which I will report.

The following cases, which have come to me in the past few years, have all been of different types and of considerable interest:

Case 1. Miss L., age 28 years. Brought in by Dr. West of Batavia, May 28, 1910. History: Born in Sweden. Had the diseases of childhood. Eight years ago had the right leg amputated in Chicago for a tubercular osteomyelitis. For many years has had crampy pains in the abdomen. Never passed blood in the stools as near as she remembers. Physical examination shows, aside from an amputated limb, the patient to be in fair condition. Anæmic; heart, lungs, and kidneys negative. Umbilicus much retracted.

On opening the abdomen we found the signoid drawn over into the right side of the pelvis. The ovaries and uterus were small. The cæcum was high up under the liver, and in looking for the appendix we found a Meckel's diverticulum about eight inches above the ileo-cæcal valve. The diverticulum was filled with gas and fæcal matter and was constricted at the bowel end so as to act as a valve. There were adhesions around it, which

were loosened, the diverticulum was removed, and the bowel opening closed by two rows of sutures. The appendix was looked for and removed, though found normal. The patient made an uneventful recovery, and reports that she has felt fine since the operation.

CASE 2. F. D., male, 6 years 6 months. Home in Kansas, and while visiting his grandparents in Aurora, was taken sick. Previous health good. The day before I was called, he had eaten several apples and was wrestling with other boys. Late in the afternoon he got severe cramps in the abdomen, which his mother ascribed to eating green apples, and he was given a physic. The pains continued through the night, and I was called the following morning. He gave no history of ever passing blood, or having had previous attacks. Examination showed face pale and pinched, pulse 140-150, weak and thready, and temperature normal. Heart and lungs negative. Abdomen: In the region of the bladder was found a large swelling, dull on percussion and moderately tender. He had passed very little urine, and by catheter very little urine was obtained. The urine was dark and contained neither sugar nor albumin. I made a diagnosis of a probable volvulus, and advised operation. A consultation with Dr. Milbacher was held and advice repeated, but owing to the absence of the father, who was in Kansas, an operation was not allowed until the following day.

The patient's condition at this time was very bad. On opening the abdomen we found the bowel black and distended. The gangrenous condition extended from the cæcum up, and involved a little over thirty inches of bowel. This was resected, the colon closed, and a lateral anastomosis by the suture method done. The patient was in bad condition throughout the operation, and died twelve hours later.

CASE 3. L., male, 5 years old. Patient of Dr. Scheller of Big Rock. Gives history of having had similar attacks before, in which he passed blood. Present attack began with severe pain in the abdomen, lasting several hours. He was given a dose of castor oil, part of which was found in subsequent bowel movement. The following day he had another attack of severe pain lasting several hours, after which his bowels did not move. On the third day he had a fæcal vomiting. Dr. F. H. Lord of Plano was called in consultation. A diagnosis of an intussusception was made, and the patient brought into the hospital.

The abdomen was opened by a median incision. Twenty-five or thirty inches of small bowel were found very much dilated, and covered with black patches the size of a dollar. A mass was found high up in the right upper quadrant of the abdomen which seemed incarcerated, and was brought out with difficulty. A loop of about five inches was intussuscepted and was gangrenous. This was resected. An end-to-end anastomosis was made with a Murphy button, and the abdomen closed. On examining the specimen we found a Meckel's diverticulum, which had become invaginated into the bowel and was gangrenous. The invaginated Meckel's diverticulum no doubt caused an increased peristalsis, causing it to be drawn farther into the lumen of the bowel, producing the intussusception. On the fifth day, the patient passed the button, and left the hospital on the eleventh day. Upon recent inquiry I have learned from the mother that he has remained perfectly well. I wish to mention that the button passed unusually early.

CASE 4. Baby E., male, 9 months old. I will speak of this case because of a very blunt diverticulum in the lower ileum, and a very long appendix in an intussusception. The case was brought to me by Dr. F. C. Nilsson of Laurens, Iowa, April 25, 1912. Dr. Nilsson was called to see the baby on account of severe abdominal pain. A week previous it had a mild attack of pain. A few hours before the second attack, the child had passed a perfectly normal bowel movement. About one and a half hours after the pain he passed about two or three ounces of blood, after which frequent bloody mucus passages.

On examination, Dr. Nilsson detected peristaltic waves and a sausage shaped tumor in the left side, and made a diagnosis of intussusception. He advised immediate operation, and came to Aurora with the child. A the time of entering the hospital the pulse was rapid and weak; the skin, which had always been of very good color, was pale, and the lips were blue. A median incision was made, which had to be extended above the umbilicus. The abdomen was filled with a serous fluid, and the tumor mass was found to be the colon, and extended across the upper part of the abdomen and down into the left side. After delivering it to the outside, and finding it impossible to reduce the intussusception without tearing the bowel, we clamped it at both ends and dissected it out. The condition of the baby being very bad, we made an anastomosis by means of a Murphy button, but it lived only a few hours.

Examination of the specimen showed it to consist of about three inches of the ileum, and twenty inches of colon. The appendix was about three inches long, and near it was a cupping in the intestinal wall. It was impossible to reduce the intussusception without tearing the bowel, which was found to be gangrenous for about ten inches.

The above cases have been of considerable interest to me, because of the comparative rarity of Meckel's diverticulum, and because each case has been different. In Case 1 it simulated an appendix both in symptomatology and also findings at the operation. The diverticulum contained fæcal matter and gas, which is an unusual finding according to the literature that came to my notice.

In Case 2 the diverticulum caused a volvulus which resembled an extremely distended bladder. The onset was very sudden and very severe, so that even a casual inspection of the child gave one an impression of collapse. His color was bad, the expression anxious, and the pulse thready, though the pain and tenderness at the time were not much.

Case 3 was more typical of the average run of Meckel's diverticulum with intussusception. There was the severe colicky pain followed by vomiting, which became fæcal on the third day. No blood, however, was passed. In this case, besides having the Meckel's diverticulum invaginated and having the bowel intussuscepted, the whole mass was incarcerated quite firmly in the right upper quadrant of the abdomen.

In Case 4, as in Case 3, we had intussusception, but involved chiefly the large bowel. The blood was passed about one and a half hours after the pain, which was no doubt due to the fact that the intussusception reached down into the descending colon, and was tightly constricted, the bowel being absolutely gangrenous.

Since reading this paper at the Fox River Medical Association I have operated on another case which I will include in the report.

CASE 5. Mr. F., 25 years old. Brought in by Dr. Thompson of Sandwich, Ill., with the following history. He had no bowel disturbances until seventeen years of age, and since then has had five attacks, feeling perfectly well in the intervals. Nine months ago he had an attack, with colicky pains and bloody stools which kept him in bed for two weeks. After that, he was perfectly well, and worked on the farm until three days ago, when he again had the colicky pains and bloody stools. The pains were sudden, to the left and above the umbilicus, and felt like gas through the bowel down along the left border of the abdomen until they seemed to reach the rectum, where it felt as though they met with an obstruction and produced severe pain. The pain lasted all afternoon, and in the evening he passed a large quantity of blood. The next morning he felt perfectly well. In the afternoon he again had the pains, and in the evening passed more blood. At the time of entering the hospital he was feeling perfectly well, but was still passing dark blood in the bowel movements. He has had no stomach symptoms, no vomiting, and no tumor could be felt. Rectal examination was negative. A diagnosis of a Meckel's diverticulum was made, and operation advised, which was done the following morning.

Operation: A median incision was made. The Meckel's diverticulum was found about eighteen inches above the ileo-cæcal valve, attached opposite the mesentery. It was about the size of an average thumb, two inches long and very much constricted at the bowel end. It was clamped, excised, and the bowel closed by two rows of linen suture. The Meckel's diverticulum was filled with dark blood, hung free, and showed no inflammatory changes. On its surface was found a white cord-like ridge which resembled a remnant of the vitelline duct. The mucosa was very redundant, thick, white in color, fairly hard, tough and elastic like cartilage. In tracing the bowel down to the cæcum we found a Lane's kink about three inches above the ileo-cæcal valve which formed a very acute angle, with the convexity hanging downward. The Jackson's membrane which supported it was a dense fan-shaped structure about five inches at its base. This was dissected off and ligated.

The appendix was six inches long, with several fæcal stones, but showed no inflammatory changes. This was removed and the abdomen closed without drain. The patient made an uneventful recovery.

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DEPARTMENT OF TECHNIQUE

A CASE OF EXTENSIVE SUBCUTANEOUS EMPHYSEMA FOLLOWING INTRATRACHEAL ANÆSTHESIA, WITH RECOVERY [1]

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KATE S., age 36, was admitted September 14, 1912, to St. Luke's Hospital, with a diagnosis of tumor of the cerebellum. Aside from symptoms immediately referable to the tumor, her general physical condition was satisfactory, the lungs being clear and the heart normal. An exploratory operation in the occipital region with a decompression was performed by Dr. Walton Martin on September 16th, with intratracheal anæsthesia.

The patient was easily anæsthetized with gas and ether (Bennett apparatus being used), and was readily intubated at first trial without apparently the slightest trauma, using a No. 24 Fr. lisle-thread catheter, and Jackson's direct vision laryngoscope. The catheter was stiffened slightly by use of cold water, as an aid to intubation. It was intended to keep the manometer pressure at 20 mm. of mercury.

It was necessary to place the patient in complete prone position, with the head strongly flexed over the end of the table; a very bad breathing position for any patient. There was considerable chance for the displacement of the catheter while the patient was being arranged in this position and draped, and in order to protect the anæsthesia in this regard, the usual close observation of the apparatus, especially the manometer, was necessarily somewhat neglected for a brief time. The draping practically excluded any view of the face, and with the assistants close around the head, it was next to impossible for the anæsthetist to make any satisfactory observations. The operator agreed to watch the color of the blood for cyanosis, and a nurse was instructed to frequently observe the pulse.

The patient was quiet, of good color, and the operation was started. It was early observed that the air was not passing through the ether with the usual freedom, indicating that the intrapulmonary resistance was excessive; but the color and pulse were entirely satisfactory for the first ten minutes. During the next twenty-five minutes all went fairly well except that a moderate cyanosis developed occasionally, which was relieved by extending the head a little. The pulse was now about 120, and the general condition was less satisfactory. About ten minutes later the blood in the wound was noted to be very dark, and the face, which was inspected at once, was cyanosed and generally swollen, especially on the left side. The intratracheal tube was withdrawn without a moment's delay, and the patient quickly turned to the dorsal position and artificial respiration begun. A more careful examination now showed that, aside from the face, there was also marked swelling as far down as the umbilicus, anteriorly, and to the base of the spine, posteriorly, all of which gave the characteristic crackle, on palpation, of subcutaneous emphysema.

The pulse now was 160, and the patient looked moribund; a gasping respiratory effort occurred about four to six times to the minute. After a few minutes of artificial respiration the color began to improve, and the respirations increased to ten to the minute while the breathing became Cheyne-Stokes' in type. Then, in a latero-prone position, with a very small amount of drop ether, a decompression was rapidly completed. On leaving the operating room the pulse was 140 and of better quality, the color was good, respirations were about twelve to the minute, body was rather cold and clammy, and the emphysema was unchanged.

During the next three or four days the emphysema mostly disappeared; rather rapidly from the face, but slowly and never completely from the body. There were no signs of pneumonia or bronchitis at any time, and no laryngitis or sore throat. Her condition was so satisfactory that on October 2nd (sixteen days after the first operation) an attempt was again made to locate the tumor, the decompression having but little relieved the pressure symptoms. The position was prone, and a successful anæsthesia was carried out with the use of warmed ether, vaporized into a partially closed mask, and pharyngeal tubes introduced to prevent obstruction. She died five days after this second operation of traumatic cerebritis. There were no pulmonary complications. Unfortunately an autopsy could not be obtained, but it is interesting to note that some emphysema still persisted about the base of the spine when she died.

The following possibilities may be considered in explanation of this accident:

First, that of direct trauma due to the catheter, either during introduction or afterward. Again, from pressure of the long, narrow sand bags under the neck.

Secondly, trauma brought about by overdistention. Here is considered the possibility of inserting the catheter too far, and thereby plugging tightly a bronchus, leading to overdistention and rupture of the lung. In this case perhaps obstruction was possible from the extreme flexion, and pressure of the sand bags beneath the neck. Again, the catheter may have been too large (No. 24 Fr. was used), but from experience this seems unlikely.

This is the second accident of this kind that

[1] Read before the New York Society of Anæsthetists, December 20, 1912.

has occurred in this city during the use of this method. The other case resulted in death, and was thought to be due to the catheter slipping into a bronchus and plugging it, with consequent excessive distention and rupture of the lung.

In closing this report it is admitted that errors in technique may have been entirely responsible for this accident; but it teaches the valuable lesson that the method is not entirely without danger, and, further, that a safety device (which was not applied to the apparatus used in either of the above cases) which will efficiently guard against high intrapulmonary pressure is absolutely essential.

A SUGGESTION TENDING TO SIMPLIFY AND MAKE MORE ACCURATE THE CLOSURE OF THE POSTERIOR EDGES OF THE WOUND MARGIN AFTER EXCISION OF SADDLE ULCER OF THE STOMACH

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THAT the operation of gastrojejunostomy alone has no permanent effect upon ulcers situated at a distance from the pylorus is a well-accepted tenet. These ulcers should be excised. There is also a widespread movement tending towards the excision of all chronic ulcers of the stomach, wherever such excision is technically possible, owing to the recognized tendency of such ulcers to take on malignant changes.

Though uniform success has so far been attained by us in ulcer excision, the writer has frequently been put to a greater or lesser degree of trouble in saddle ulcer in closing the wound margins on the posterior wall of the stomach, depending upon the area of tissue excised. The method heretofore pursued has been that of bringing together the margins of the wound with a running suture of catgut, taking up all the layers of the stomach wall, beginning posteriorly at the lower angle of the wound and ending at the lower end of the anterior wound. Over this is then placed a continuous suture of linen, approximating the peritoneum in the usual way, beginning and ending at the same points as in the first layer. In the placing of this last suture it has been found difficult in several cases to rotate upward and forward the posterior wall of the stomach for the purpose of accurately reaching the wound margin. This should begin a little below the first layer, in order to carefully protect from leakage at this lower posterior angle especially.

In a case recently operated and in which a saddle ulcer 4 cm. from the pyloric ring was excised, the following procedure was employed with successful issue: Clamps were used, and a goodly margin of tissue allowed around the indurated area. The posterior wound lips extended well downwards, a little more than one half of the stomach diameter being involved. With double tenaculum forceps the lower angle of the wound was held, and with a similar instrument the margins of the wound were approximated at the lesser curvature. A running lock stitch of No. 2 plain gut was now placed, beginning at the lower angle of the wound and taking up all layers of the stomach, ending at the lesser curvature, where it was tied and allowed to remain. This completed, slight upward and forward traction was made along this line of suture. Now the second suture was begun, consisting of medium weight linen, commencing slightly below the lower extremity of the ridge made by the first layer, and passing from side to side of this ridge, in continuous mattress style, from the starting point to the lesser curvature where the first layer ended. This was not tied at its upper end, but the needle passed through so as to emerge on the peritoneal surface, and the thread allowed to remain long for subsequent use. During the passing of this layer the finger of one hand was held behind the stomach as a guide. The approximation of the posterior wound margins now having been completed, the end of the catgut suture which had remained was picked up and the anterior margins brought together after the usual fashion. This in turn finished, the long end of the linen thread was used again, and the peritoneal surfaces of the anterior stomach wall were approximated by a continuous Cushing suture passed in the usual manner.

It will be seen that the usual method has been utilized throughout, except that on the posterior surface the peritoneal apposing suture passes through all of the coats of the stomach, being passed from the inner side, which greatly simplifies the placing of this layer. It has been

shown by numerous observers that while theoretically such a suture is contaminated by the contents of the viscus, practically and clinically such contamination may be disregarded, more especially when dealing with the stomach.

As far as we are able to ascertain, this method is original with the writer. It is submitted that the introduction of the posterior peritoneal apposing suture is by this means facilitated; and by this fact that a greater surety against leakage from this part of the wound, the most troublesome to handle, is to be had.

EXPERIENCES WITH INTRAVENOUS ANÆSTHESIA

Preliminary Report

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AND

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SURGERY of to-day has made rather exacting demands upon the anæsthetist, the operator insisting upon a period of stable anæsthesia of indefinite duration, with complete relaxation of the subject, minimum risk, freedom from post-anæsthetic nausea and vomiting, and finally the absence of the more severe complications in the post-operative stage usually ascribed to the anæsthetic. Even the layman, with an exaggerated idea of the safety of modern surgical procedures, usually disregards the potential factor in operative risks, but almost invariably raises the question of danger from the anæsthetic when about to submit to operation. These combined demands have created the "specialist in anæsthesia," whose energies in the past few years seemed to have almost exhausted the possibilities of their art as to agents and methods and in the development of apparatus, each time returning to the point whence they started in 1846 — the administration of ether. Of the newer methods, rectal anæsthesia had but little to commend it and was soon disregarded. Spinal anæsthesia,— even though espoused by enthusiastic advocates in this country and demonstrated by distinguished confrères from abroad, has not been sufficiently convincing to give it a prominent place in the armamentarium of the American surgeon.

It has been pointed out by Hewitt (1) that: "General anæsthesia, with its attendant unconsciousness of all of the surroundings of a surgical operation, is immeasurably preferable to local or regional anæsthesia, and it is to development in the former system, rather than in the latter, that attention should be devoted if the science is to be brought to its legitimate level." Notwithstanding that intravenous anæsthesia has been practiced in various clinics abroad, the procedure has not appealed to our anæsthetic specialists, who probably considered it either a method of doubtful utility or the passing fad of the moment.

Experience, however, shows that this method possesses undoubted advantages, and while not in any way advocating the intravenous route as the usual method of inducing anæsthesia, its claims for use in certain cases and conditions cannot well be gainsaid. By the indirect or respiratory method of anæsthesia, volatile agents are employed which enter the blood in a volume or dosage which varies with the depth and energy of the respiratory act, with the degree of accidental spasm of the muscles concerned in the act of breathing, and the absorptive power of the bronchial mucous membrane. This method does not produce a smooth, even narcosis, as the factors utilized are subject to much variation, and the amount of anæsthetic used must always be in excess of what is actually required to produce the result in any given case.

The excess of anæsthetic is thus stored up in the body to be gradually eliminated, a process requiring some days, and not until the organism experiences some deleterious effects of the retained drug. In the employment of intravenous anæsthesia the agent is directly introduced into the blood, a minimum amount is used, it is maintained there at a certain definite percentage, and its employment can be withdrawn abruptly without storing up in the body reservoirs such excess as may subsequently prove harmful to the patient In this method the production of anæsthesia is very rapid, the preliminary stage of excitement nearly always absent, the patient breathes almost

naturally, the color of the skin remains good, and the relaxation and flexibility of muscles are absolutely satisfactory to the operator. The degree of narcosis can be maintained to a nicety, and at the completion of the operation the patient often answers questions rationally before leaving the operating room, and returns to bed with better physical signs than before the anæsthetic was administered.

It cannot be too strongly urged that, for the successful induction of this form of anæsthesia, very careful attention must be given to what are apparently trifling details of the technique. The failure to recognize this fact was the reason of only partial success in the hands of some of our interested confrères.

For the intravenous use of ether the patient, having been prepared, is taken about forty minutes before the time for operation to the anæsthetizing room and placed preferably upon the operating table which is to be used during the operation. A subcutaneous injection of scopolamin gr. 1/100, atropin sulph. gr. 1/100, and morphin sulph. gr. $\frac{1}{6}$ is given in one dose, in the loose tissues of the chest or abdomen. From this time until the actual anæsthesia is accomplished it is extremely advisable to keep the patient as quiet as possible, so that its administration is begun with the patient in a condition of reposeful relaxation of mind and body. This precaution materially shortens the first stage and induces prompt anæsthesia with the least amount of solution, and economy in this direction is much to be desired.

Our first experience was with ether, using the simple infusion apparatus as recommended by Burckhardt (2), the originator of the method, but subsequently in all administrations, we used the more elaborate and satisfactory technique of Rood (3). A five per cent solution of ether with filtered sterile normal saline solution at a temperature of 96° is poured into a reservoir which has a capacity of 2,000 cc. and which is adjusted on a stand eight feet above the floor level, at which point it remains during the administration. The fluid flows through an indicator (which contains a pipette), then through a warming chamber into a blunt cannula, and so into the vein. The indicator consists of a cylindrical or globular bulb of a capacity of from 2 to 4 oz., with an inside pipette, very much as used in Murphy's apparatus for protoclysis. When the apparatus is working properly, the lower half of the indicator is filled with solution while the upper half contains air. The solution flows from the tank through the pipette and drops on the surface of the fluid in the lower half of the indicator. By means of a compression tap placed below the indicator, the rate of flow can be accurately controlled, and if the fluid in the bulb is kept at a proper level a satisfactory index is furnished as to the rate at which the solution enters the vein. As ether boils at 98.6°, it is very important to keep the solution below that point, as the agent is so volatile that it usually vaporizes and escapes if the temperature is raised even for an instant above 96°.

Usually the arm furthest from the operator is selected and bound at the wrist to a padded splint, which extends under the body to the opposite side, the weight of the body holding it in place. Or the arm may be bound lightly to a splint extending from wrist to axilla and resting on a table of convenient height. This effectively prevents flexion of the forearm. The bend of the elbow is wiped with 5 per cent solution of thymol in carbon tetrachloride, which is preferable to the usual iodine application, as it is more effective as a disinfectant; and as it does not discolor the skin, the position of the vein is easily determined. After anæsthesia of the skin is induced by a 0.5 per cent solution of cocaine, the median basilic vein is exposed through a small incision one half to one third of an inch long, and a double catgut ligature passed beneath it. The distal one is tied and the ends left long and handed to an assistant, who uses it as a tractor. By lifting on both ligatures, the vein is lifted from its bed and with scissors is incised through about one half of its diameter. Into this opening in the vein a blunt cannula is introduced and tied with the proximal ligature.

The solution should be administered at a full flow at the beginning, the anæsthetist reducing the stream at the appearance of the usual signs of surgical anæsthesia. It is quite incumbent upon the anæsthetist to take the usual precautions to secure and maintain an unobstructed air way and efficient respiratory act, as with the usual method of anæsthesia. Ether is rapidly eliminated by the lungs in this method, and, as is true of all methods, efficient respiration prevents accumulation and tension in the tissues, increases its output, and lessens its toxicity. In from one to five minutes anæsthesia will be complete and the operation may proceed. Oozing is more noticeable perhaps in the operative field, and with this method, if the cavity of the abdomen is the seat of the operation, fluid rapidly accumulates there. If extensive adhesions are to be dealt with, the fluid becomes blood-stained, and there might be instances where this might embarrass the oper-

ator. But we have not been so troubled. The patient may be brought from one degree of anæsthesia to another very rapidly by the judicious use of the control indicator, and it is well that the operation be entirely finished and dressings applied before the administration, which has been continuous, is stopped, as the patient returns to consciousness very quickly.

The employment of ether in this way seems almost devoid of danger, either from immediate or remote complications, notwithstanding the fact that the infused fluid must be kept at a temperature lower than 98.6°. We have had no case of chill or fever follow 1,800 cc. administered at a temperature of 96°. This is about the only essential precaution in the intravenous administration of ether.

Having been successful in a number of cases with ether, our attention was directed to the use of hedonal in 530 cases reported by Fedoroff (4), collected from three Russian clinics. No death attributable to the anæsthetic occurred in any case, though eight cases of respiratory arrest occurred, which yielded to methods of artificial respiration.

Hedonal, or methyl-propyl-carbinol urethrane, is a white crystalline solid stable powder, soluble in water at a temperature of 100°. In doses from 15 to 30 grains it has been very successfully used as a pure hypnotic. It is, to some extent, a diuretic, does not depress the action of the heart, and in lethal doses destroys life by respiratory arrest. No fatalities attributed to the use of hedonal as an hypnotic have yet been reported.

For the induction of anæsthesia, the drug is dissolved in a normal saline solution at a temperature of 70° to make a 0.75 per cent solution. The resultant fluid is filtered and brought to a boiling point; we prefer not to boil five minutes, as recommended by Page (5), as some of the efficiency is lost by volatilization of a certain amount of the compound due to prolonged boiling. The tank is filled, and when ready to begin the fluid should be about 115°. The same method as used with ether is employed, the fluid being allowed to run in rapidly. Greater caution is necessary with hedonal than with ether, the effect is much quicker, and on the appearance of signs of deep narcosis the stream is reduced until it flows guttatim from the pipette in the indicator. The patient quickly becomes drowsy, the face flushes, or, if the flow is too fast, may be slightly cyanotic, the pupils usually contract, the muscles relax, the corneal reflex is absent, and the patient seems to be in a condition of sound normal sleep without the noisy respiration of an anæsthetic. Observation of the corneal reflex determines the rate of flow, which after a little experience can be regulated to the satisfaction of operator and anæsthetist. For operations lasting from 15 minutes to one half hour the patients often wake quite promptly, but with larger administrations they may sleep six to twelve hours, during which time they may be awakened, but they readily fall asleep again. The blood pressure always falls with the use of this drug in this way, and in one of our demonstrations before the Society of New York Anæsthetists we purposely selected a case with a very high blood pressure (186 mm.), which promptly came down to 142 mm., and so remained for several days after operation. In all we have had 51 administrations without a fatality and without a complication worthy of mention, a transient diarrhœa in our very first ether case, and a slight bronchitis in a frail subject after the removal of a colloid goitre weighing nearly two pounds. The class of cases has been those that have come in ordinary general hospital service, laparotomies for uterine fibroids, pyosalpinx, ovarian cyst, appendicitis, uterine suspension; hernia, joint resections, arthroplasties, amputation of thigh, bone plating operations, plastic operations on cervix and perineum, removal of laryngeal growth, goitre, operations for varicose veins, and castration. The case of ovarian cyst was noteworthy: a woman aged 67 had been tapped 36 times. The cyst wall weighed 15 pounds, and though some of the contents was lost, ten gallons were actually measured. Ether was used in the case; the anæsthesia was a perfect success, the patient showing no untoward symptoms at the end of the operation, notwithstanding the sudden withdrawal of so much fluid; and the post-operative record was comparable to that of a minor operation.

We had one failure with ether in one of the early cases, due to allowing the temperature of the saline solution to be above the required point. One of us (Hassler) prefers ether on account of its efficacy and safety, but the other one (Honan) favors hedonal as possessing most of the characteristics necessary for this form of anæsthesia. It can be sterilized, is stable, capable of accurate dosage, prompt, efficient, reduces blood pressure, and, more important, seems to fulfill the purpose, as expressed in Dr. Crile's idea of anoci-association, of preventing cerebral bombardment by shock impulses. There is no question but that the appearance of the patients after operation indicates that this contention is probably true. It has been suggested that the use of hedonal in this manner may be extremely useful in controlling

the convulsions of uræmia, particularly of the puerperal type. Its sedative action, its power to lower the blood pressure, and the diluting and eliminating effect of the saline, or preferably an isotonic glucose solution, in this instance opens up a field in speculative therapeutics that might prove of inestimable value.

We have also experimented, in two cases, with paraldehyde, but our findings do not warrant its adoption without further experience. Ether has always raised the blood pressure from 2 to 20 mm., while with hedonal it falls from 10 to 12 mm. One case, purposely selected, with a blood pressure of 186 mm., dropped to 142 mm. and remained at the lower level for some hours. There have been no evidences of hæmolysis other than occurs in ordinary saline transfusion, or in the respiratory method of giving ether. Hedonal seems particularly well borne and shows no very definite blood changes, but with paraldehyde the microscopic field shows occasional blood cells with marked crenation and pigmented spots in the cell body. In a subsequent paper this part of the subject will be particularly discussed.

The time required to produce complete anæsthesia ranged from one and one half to twenty-three minutes with ether, while with hedonal the time was from twelve seconds to four minutes. We kept one patient under ether for one hour and twenty-eight minutes, using 2,100 cc. of solution (about 3 oz. of ether); another with hedonal 175 grains in 1,600 cc. of solution.[1] No case of right heart dilation was noted, though the Trendelenburg posture was used in cases for which it is adapted. The cases were marked by absence of nausea and vomiting in every instance, comparative freedom from post-operative pain, absence of thirst, and rapid restoration of functional activities of the body. The mental status, particularly after the use of ether, is markedly clear; the patients are happy, and those who have experienced other forms of narcosis express a preference for the intravenous method of anæsthesia.

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[1] Since writing the above we have used a mixture of paraldehyde 2½ per cent and ether 3 per cent in normal salt solution in five cases with very satisfactory results.

Z-PLASTIC SURGERY

Plastic Operations to Elongate Cicatricial Contractions of the Neck, Lips, and Eyelids and Across Joints

By STEWART L. McCURDY, M. D., Pittsburgh

Professor of Oral Surgery, University of Pittsburgh; Orthopædic Surgeon Columbia and Presbyterian Hospitals

IT is a difficult problem, in the surgical management of old cicatrices across joints, about the neck, or between the fingers, to liberate the deformed members and control the tissues so as to guard against a return of the same deformity after complete repair has occurred.

The usual method of severing the contracting band at right angles to the line of deformity promises little toward permanent relief of the deformity. The suggestion that an eyelet be made as a preliminary step before severing the tissue to the margin is not satisfactory. All sorts

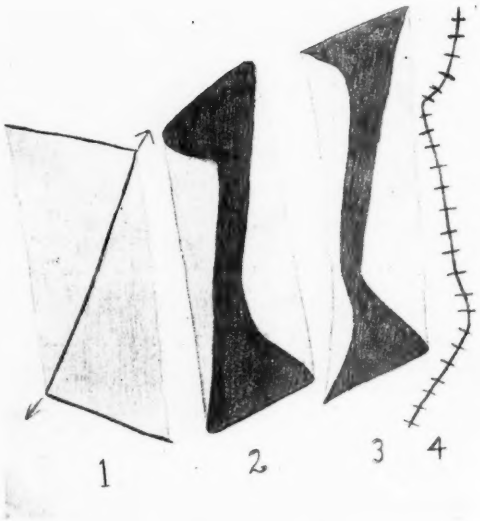

Fig. 1. (1) Line of incision and shaded area showing where skin should be dissected from the other structures. (2) Showing partial extension of contracted tissues. (3) Showing further extension. (4) Showing complete extension and adjustment of flaps with sutures. Observe that the central part of the wound is covered with skin.

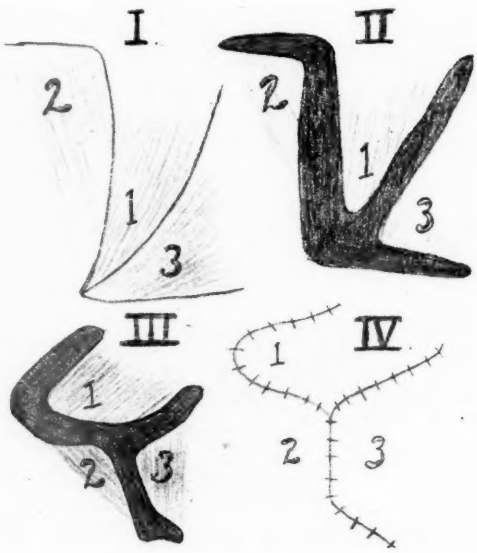

Fig. 2. (1) Modified Z incision. (2) and (3) Intermediate position of the flaps as they were shifted from their original to their new position. (4) Completed suture.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 3. The Z-line shows the incisions. After these were made, flaps A and B were dissected loose back of the dotted lines. The second step in the operation is to take flap B and switch it over into the space left underneath the mandible on the left side, after dissecting loose flap A.

Fig. 4. Flap A is drawn downward and below flap B and sutured in its new position. It will be observed that originally flap A was attached to the symphysis, but finally was sutured to the skin immediately over the sternum; and that the angle of flap B, originally attached to the skin immediately over the sternum, was shifted so as to be sutured to the skin immediately under the left angle of the mandible.

Fig. 5. Final result. This operation was performed twenty years after the original burn. Notice, in Fig. 5, there is no traction upon the angle of the mouth and that the face has assumed an entirely different expression, and that the neck line is perfect throughout the entire circumference.

Fig. 9. Burn scar under the arm. Operation by the Z method.

Fig. 10. Result after complete repair. Observe the Z-line of incision across the axillary space.

of plastic operations are constantly being done, and some are successful.

For bands across joints, as at the elbow, and in cicatrices of the lips, eye, neck, or fingers, the practice is to make an incision along the crest of the band from end to end, care being taken to separate the two layers. A lateral cut is made at each end of the first, but on opposite sides, back

Fig. 6.

Fig. 7.

Fig. 8.

Figs. 6 and 7 represent practically the same operation as shown in the preceding case, with equally good result. Fig. 8 is introduced to show neck cicatrix and ectropium of the lower lip corrected by the Z operation described in the text in this chapter.

Fig. 12.

Fig. 13.

Figs. 12 and 13. The above pictures represent a case of web fingers following severe burns of the hand from naphtha gas. Operation performed was that described in the other cases. The little finger deformity is due to the fact that the original burn entirely destroyed the joint, and bony ankylosis resulted.

to the edge of the cicatrix. The angles of the flaps thus made are dissected back for a short distance as shown in Fig. 1 (1). As the head is extended, traction is made on the skin at the end and a condition as shown in Fig. 1 (2) results; with further traction a condition as shown in Fig. 1 (3) is obtained. The margins of the flaps made by the longitudinal cut slide upon each other, while the end incisions are almost obliterated by the extension. The flaps are liberated as may be necessary to permit complete extension. The edges of the skin, or cicatricial tissue, as it may be, are brought together and sutured as shown in Fig. 1 (4). This may not be possible near the ends, but in the center it is usually not difficult. The advantages claimed for this method of operation are:

(1) That the central part of the tissues operated upon is always covered with normal skin, or healed cicatricial tissue, and that repair takes place in the center without further contraction of the original scar.

(2) That when sufficient skin cannot be secured to cover the entire surface of the wound caused by the operation, the uncovered portions are at the ends of the scar, or at points where there is little danger of cicatricial bands reforming to produce the original deformity.

Fig. 11. Showing result after operation on another case. Contractions were more extensive than in Fig. 9, extending practically to the elbow. Observe the normal skin in the axillary space which was switched to this position from the chest wall.

Fig. 14. Z-plastic operation of the neck for burn scar, taken sixth day after operation, before removal of stitches. Observe healthy skin in the upper flap interposed through the center of the original burn scar, which destroys the continuity of scar, thus avoiding any possible mento-clavicular contraction.

THE WHITEHEAD OPERATION FOR HÆMORRHOIDS

A Report of 200 Cases

By LLOYD NOLAND, M. D., Cristobal, Canal Zone
Chief of Surgical Clinic, Colon Hospital

IN attempting to determine the safest and best method of operating for the relief of internal hæmorrhoids, the average surgeon finds himself confronted by numerous and widely differing opinions as to the best method of performing this comparatively simple operation.

In 1882,[1] again in 1887,[2] Whitehead presented an operation which seems ideal in the light of modern surgery, affording, as it does, a means for complete removal of the diseased area with absolute preservation of the function of the parts, immediate closure of the operative wound, and permanency of cure.

The writer's excuse for presenting this operation in rather minute detail is his firm belief—after an extended use of other methods—in its superiority for the radical cure of those cases which show an almost complete circle of broad-based piles extending well above the sphincter, as well as the less marked cases involving a large part of the circumference of the rectum and also the fact that the operation seems to have fallen into disuse in the United States. This is believed to be largely due to a misconception of the technique involved, and to imaginary dangers which are not borne out by actual experience. With the exception of one article recently published,[3] I have been unable to find in the literature at my command any detailed description of the technique as presented in this article.

The principal objections raised to this operative method have been: (1) hæmorrhage during operation; (2) impairment of function, such as incontinence, stricture, etc., and (3) difficulty of the operation and the time required.

The results published in this paper are based on 200 consecutive cases operated on at Colon Hospital by the writer and his assistants, and covering a period of six years (January, 1906, to January, 1912). Nothing original is claimed for the technique, which, though different in some respects from that of Whitehead, is in many respects similar to that of Bloodgood and McGlannan. The cases were classified as follows: white male, 109; white female, 32; black male, 42; black female, 17. The oldest patient operated on was 69, and the youngest 17. There were no fatalities. There was no case of serious hæmorrhage, nor were symptoms referable to loss of blood at any time observed. Two cases developed constriction at the anal orifice subsequent to operation. Both, I believe, were due to faulty performance of the operation, and both were entirely relieved by multiple incisions of the constricting scar with dilatation. One case resulted in partial incontinence, extending over a period of three months, with gradual improvement and complete restoration of function at the end of that period. No case of recurrence has come under observation, though a large majority of the cases have been seen frequently. There was no case of secondary hæmorrhage or infection. Seventeen cases with history of previous operation by other methods are included in this series. While these cases were slightly more difficult to operate than primary cases, all made good recoveries, with apparently complete cure. Comparatively speaking, the operation can be rapidly performed, no case in our series extending over 30 minutes, the average being under 25 minutes. While there is more loss of blood than with the ligature or clamp operations, there was never sufficient loss to be at all alarming, or to have any appreciable effect on the patient. Post-operative retention of urine has not been a serious factor, many patients voiding without difficulty and most of the others requiring only one catheterization. No case in the series required more than four catheterizations. Post-operative pain is slight and easily controlled.

PREPARATION OF THE PATIENT

No food is given for at least twelve hours previous to operation. Castor oil, 1½ ounces, is administered eight hours previous to operation. An enema is not employed if free evacuation of the bowels follows the castor oil.

Ether is the anæsthetic of choice, and was employed in 174 of the cases in this series. Stovaine spinal anæsthesia (5 cg.), fourth lumbar injection, was employed in 26 cases, in which, for various reasons, ether seemed contraindicated. No ill effects were observed following the use of stovaine, and the anæsthesia and relaxation of the sphincter obtained were highly satisfactory.

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[2] Whitehead, Brit. Med. J., 1887, 1, pp. 449–451.
[3] McGlannan, Old Dominion J. M. & S., June, 1911.

Fig. 1.

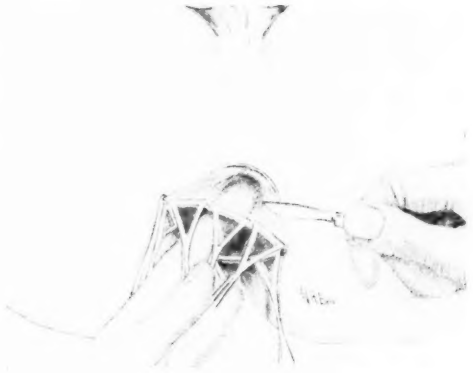

Fig. 2.

With the patient in the lithotomy position, and the buttocks drawn well down over the edge of the table, the external field is carefully shaved and scrubbed, and the sphincter dilated, either with a conical dilator of the Kelly type or kneaded with the thumbs, until full dilatation is obtained. The rectum is then thoroughly flushed out with warm water. A sphincteroscope is then inserted, and through it a gauze sponge deposited well up in the rectum. The external field and the lower rectum are gone over with 60 per cent alcohol and 1–5000 corrosive sublimate solution.

THE OPERATION

With the sphincter fully dilated and the hæmorrhoidal masses in view, T clamps are carefully placed around the entire circumference of the bowel at the mucocutaneous junction (Fig. 1). Care must be taken to grasp only the barest edge of skin. With the left forefinger in the rectum, as a guide, an incision is then made through the skin around the entire circle, keeping closely against the upper edge of the clamps. When this preliminary incision has been completed, traction is made on the clamps and with free strokes of the scalpel the sphincter is exposed (Fig. 2). If the forefinger is used as a guide and care be taken that the strokes of the scalpel are made at right angles to the guiding finger and close to the retracting skin margin, a very rapid exposure of the entire circumference of the sphincter can be obtained, with little or no hæmorrhage or tearing of the tissues. The lowest attachment of the muscle to the bowel is then freed with a few strokes of the scalpel and the muscle rapidly rolled back, using the side of the scalpel blade or handle, until the hæmorrhoidal area is passed. The clamps should now be reset, close together, around the entire circle, grasping normal tissue just above the hæmorrhoidal area. Care should be taken that the dissection has been sufficiently complete to allow that portion of the bowel at the upper edge of the reset clamps to be brought to the skin margin free of any tension, and that no portion of the muscle is in the grasp of the clamps. The whole field is then flooded with hot normal saline solution until all oozing has ceased. An incision is now made in the long axis of the bowel (Fig. 3) extending to just above the line of the clamps, and the first suture is taken from skin through mucous membrane at its apex. The line of sutures is continued around the circumference of the anus by cutting along the clamp line a small section at a time, (Fig. 4) each section being carefully sutured at cut. The operation is completed with the removal of the rectal sponge, flushing off the suture line with normal saline solution, and the insertion of a gauze-wrapped rubber tube, about ¾ inch in diameter, thickly coated with iodoform ointment. No tension sutures are employed, the necessity for these being overcome by a dissection extending high enough to make an easy approximation of the parts, absolutely free of tension. Ligation of bleeding vessels is rarely, if ever, necessary. The only bleeding of importance usually encountered is from the vessels in the walls of the rectum proper. By putting a slight lateral tension on each small section as cut, and introducing the sutures at a very slight angle to the long axis of the bowel, the bleeding in these vessels is easily controlled by the sutures alone. Interrupted sutures are employed, the number varying from 18 to 30. Any fine non-absorbable suture material can be used. We have found Pagenstecher yarn by far the most satisfactory.

Fig. 3.

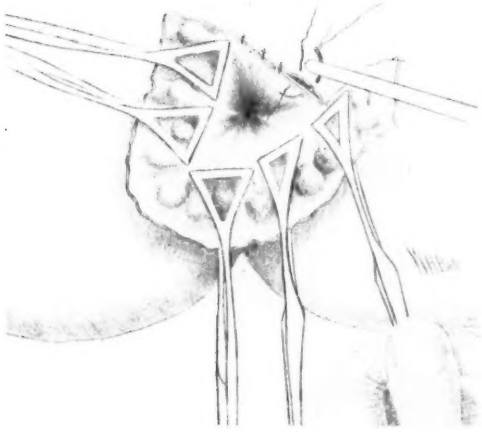

Fig. 4.

An accurate approximation of gut to skin is essential to the success of the operation, and special care should be taken that there is no puckering of skin or bowel in any way decreasing the size of the anal outlet. Ordinarily, good surgical technique — a careful dissection carried sufficiently high to allow normal gut to be brought to the skin line without tension, the use of many interrupted sutures, with careful approximation of the tissues, bearing in mind always the fact that the anal orifice should easily admit two fingers without tension on the suture line — will, I believe, give uniformly good results with no fear of stricture, hæmorrhage or infection.

POST-OPERATIVE TREATMENT

The rectal tube is removed in 24 hours. Iodoform ointment is applied two or three times a day for three days. On the fourth day a dose of castor oil sufficiently large to obtain a free evacuation is given. The operative field is flushed off after each defecation, up to the fifth day. The sutures are allowed to separate and come away without interference. This is usually accomplished within ten to twelve days. The patient is allowed to leave his bed on the fourth day and can usually be discharged from hospital by the seventh day.

I wish to express my thanks to Colonel W. C. Gorgas, Chief Sanitary Officer, Isthmian Canal Commission, for permission to publish this paper, and to Surgeon Wm. H. Bell, United States Navy, and Superintendent of Colon Hospital, for his kindness in preparing the accompanying drawings.

THE CURE OF PROCIDENTIA UTERI IN ELDERLY WOMEN

A New Intra-Abdominal Technique

By FRED FLETCHER, M. D., Columbus, Ohio
Surgeon to Grant Hospital

THE discussion accorded uterovaginal prolapse at the last meeting of the American Medical Association (1), convinces one that there has been no general agreement among surgeons as to the best method of operating. Practically 100 per cent of the cases operated upon by amateur surgeons recur, and patients who have been operated upon according to certain recognized principles by competent men, not infrequently return complaining of discomfort from cystocele.

The Kocher (6) Crile (7) Eastman (8) and Mayo (9) are recognized abdominal operations for the cure of procidentia.

The Watkins-Wertheim, Goffe (2), Hirst (3), and Dudley methods are cited as the most satisfactory vaginal operations. The Wertheim technique supports the bladder by interposing the uterus—turning it upside down. An incision is made through the anterior vaginal wall; the bladder is freed, the peritoneum opened, and the fundus of the uterus pulled forward between the bladder and vagina and sutured. The operation is completed by amputating the cervix and repairing the posterior vaginal wall. The technique is not difficult, and the dangers of injuring the bladder are minimized if the surgeon bears in mind that the blue veins, easily seen in making the gauze dissection, rest immediately upon the bladder. The Wertheim procedure has the advantage of conservatism, and meets the requirement of those who argue that an abdominal incision adds an unnecessary element of risk to a class of patients normally obese.

Baldy, of Philadelphia, in a recent article (4), described a new technique for the cure of procidentia. The intra-abdominal features of his operation (except the cervical fixation) have for years been practiced as a routine at the Grant Hospital in the making of supravaginal hysterectomies. Personally, I have used the procedure described by Baldy, and discarded it only when convinced that the operation to be detailed later gave better end results. The point made with regard to the attachment of the cervix stump close to the pubic bone is the important feature of the Baldy technique, and obtains in the operation which I practice.

The following procedures have been used by me for the past four years, and the results which

Fig. 1.

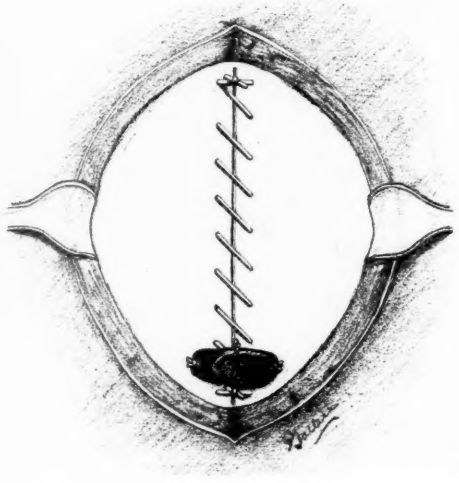

Fig. 2.

I have obtained in a considerable number of cases justify this report. There are certain features of the intra-abdominal work which, to my knowledge, have not been recorded.

The operation is essentially an abdominal hysterectomy, the uterus being amputated at the internal os, and the stumps of the broad ligaments, together with the round ligaments, being utilized (according to the Gilliam principles of suspension) as a secure means of supporting the cervix stump and bladder close to the pubic bone. The abdominal operation is preceded by the following plastic operations on cervix and vagina:

Amputation of cervix. The usual high amputation is made, thoroughly removing the mucous membrane from the cervical canal, and closing the stump with four deep sutures of No. 3 chromic gut.

Anterior colporrhaphy. An oval denudation is made, extending to within one half inch of the urethral orifice, over the most prominent part of the cystocele. It is important to conserve the fascial layers, stripping them by gauze dissection from the vaginal membrane. The bladder is thoroughly freed and the defect closed with a purse-string suture of No. 3 chromic gut.

Perineorrhaphy. The relaxed posterior vaginal wall is resected in a rectangular manner, widely exposing the rectocele and retracted levator ani muscles in the lateral sulci. The defect is closed by means of a Waldo figure-of-eight stitch, using No. 4 chromic gut (5). Before tying the stitch, a suture is passed through the levator ani muscles so that when tied they form a bridge across the rectocele and push it back in hourglass fashion. The Waldo stitch is tied by pulling in a seesaw manner.

ABDOMINAL TECHNIQUE

The abdomen is opened through a short suprapubic incision which splits the inner border of the right rectus muscle. A supravaginal hysterectomy is made, severing the broad ligaments flush with the uterus, and dividing the cervix at the internal os. The cervical canal is touched with iodine. The ovarian and uterine arteries are ligated. The tubes and ovaries are removed with the least possible destruction of the broad ligaments. It is a curious fact that the procidentia cases are usually clean; the body of the uterus being small, the tubes and ovaries normal in appearance and the ligaments relaxed. The heavy part of the uterus is the vaginal segment.

The fat on either side of the incision is freed from the abdominal aponeurosis, and a one-half-inch cut is made through the aponeurosis at the outer border of the rectus muscle. A pointed hæmostat is introduced through this cut in such a manner as to separate the muscle fibers and bulge the peritoneum, the latter being opened with a pair of curved scissors. The stump of the broad ligament is now grasped with the hæmostat and pulled through the opening made in the abdominal wall, exactly as in the Gilliam method of suspension for retroversion.

When the broad ligament stumps have been delivered through the abdominal wall they are drawn taut so as to pull the cervix stump in the lower angle of the incision immediately above the pubic bone. Fixation of the cervix stump is comparatively easy. A curved needle (carrying No. 1 chromic gut) catches the muscle and peritoneum, to the side, at the lower angle of the abdominal incision, passes through the posterior layer of the broad ligament, then through the side of the cervix stump, and out through the anterior leaf of the broad ligament, returning to the starting place. The suture is not tied until the same procedure is practiced on the opposite side. The tying of these sutures fixes the raw surface of the cervix stump to the peritoneum and approximates the two layers of the broad ligaments, which are always separated at the point where the uterus is amputated (Fig. 1).

The abdominal wall is closed in the usual layer fashion, using No. 2 chromic gut for the aponeurosis. The broad ligament stumps and the redundant round ligament form broad serous flaps which are overlapped and sutured above the aponeurosis in the manner shown in Fig. 2.

Aside from the benefit which results from plastic work in the vagina, the intra-abdominal procedure accomplishes what Baldy points out for his technique (4), namely; (1) The weight of the heavy uterus is removed, (2) the overstretched vagina is lifted high and held firmly in place, (3) the supports utilized are natural supports of the uterus and vagina—the broad ligaments, (4) the cervix remains a pelvic organ, as is natural, and (5) the immediate and remote results, as regards fixation of the upper part of the vagina, are perfect.

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HOW TO SECURE THE END OF A SUBCUTICULAR SUTURE

By FRANCIS REDER, M. D., St. Louis

THE subcuticular suture as given to us by Halsted is a splendid suture. In certain parts of the body, such as the face and neck, it is not only admirably adapted, but it is the suture of choice.

When properly applied it leaves a scar that in the course of several months becomes almost invisible. The suture has not found the favor with surgeons that it should. Why? It is true its method of application requires some special practice. In surgical work that is not at all strange. The polish of a finished surgeon is the result of work that comes after years of close application. It is immaterial whether or not the surgeon uses a large straight needle or a small curved needle (that is a fancy which rests with his deftness) in penetrating the proper stratum of the skin that a classic wound closure may be obtained; it is material with him, however, how to best secure the end of the suture after having united the skin margins.

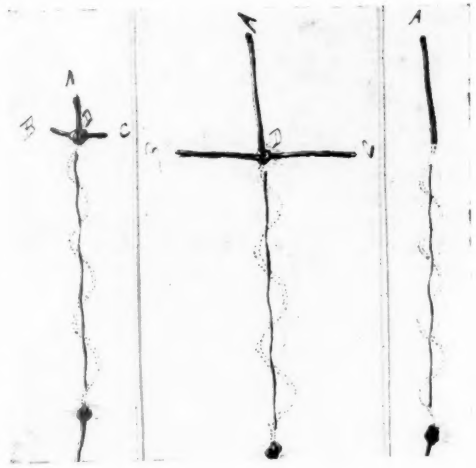
In my observations of the work of different surgeons working with the subcuticular suture, this very point seems to be a stumbling-block. It appears to me that here lies, to a great extent, the cause for the limited usage of this efficient suture.

Some surgeons, after having finished the subcuticular stitch, secure the end by simply piercing the skin with the needle armed with the catgut two or three times a short distance away from the angle of the wound, in that way anchoring the suture end. Others pierce the skin near the angle of the wound and tie a knot by looping one side of the suture. Such a procedure is not in accord with the idea of a subcuticular suture. It defeats its object and mars its beauty. There is no necessity for it and the scarring it causes, mild as it may be, is uncalled for.

I have for a number of years, whenever the subcuticular suture was employed, secured the end in this manner:

The suture is started by having the end of the catgut strand well knotted so as to form a good point of resistance to the skin. The skin margins are brought and held in apposition by the stitch best suited to the operator's skill.

When the opposite angle is reached, in order to secure the suture, the needle is passed under the skin in line with the axis of the closed wound and



the catgut strand pulled through the skin about one-fourth of an inch from the angle of the wound. The protruding end should be two to three inches long at least. A separate piece of the same catgut strand about four inches long (long enough to be conveniently handled) is tied about its middle to the protruding strand "A" at its base "D." A simple and single knot is all that is necessary. We will designate, for the sake of a clearer understanding, the ends of this strand "B" and "C." Next strands "A," "B" and "C" are tied together at "D" in a firm knot, large enough to offer the proper skin resistance. This knot will be effective in securing the suture without any additional trauma to the skin.

The strands "A," "B" and "C" are cut short.

It may be stated that the correct application of a subcuticular suture can be very satisfactorily executed with numbers 0, 1, or 2 plain sterile catgut. Good flexibility and pliability of the catgut is a qualification which is of considerable technical importance.

For the past four months we have stored the gut in McDonald's acetone-alcohol-glycerine solution (Am. J. Surg., May, 1910), with results superior to those obtained when stored in plain alcohol. This solution renders the gut smoother and stronger without decreasing its elasticity and pliability.

OBSTETRICAL AND SURGICAL TREATMENT OF PUERPERAL ECLAMPSIA[1]

By JOHN F. MORAN, M. D., Washington, D. C.

ECLAMPSIA is the gravest complication in obstetrics; grave because of its unknown etiology; grave because of its known pathology, showing the presence of a highly irritating toxin in the circulation, and grave because of its often sad result, the loss of both mother and child.

Upon whatever theoretic basis we may predicate the etiology of eclampsia, whether of fœtal, maternal, or combined origin, the one incontrovertible fact is that pregnancy at least is necessary, for without pregnancy there can be no eclampsia. Therefore, the therapeutic conclusion must be that in eclampsia prompt termination of the pregnancy, through the quickest possible delivery consistent with safety, is of primary importance. It is quite possible that the eclamptic may withstand the attacks without immediate delivery, and the birth may terminate safely. It is nevertheless true that many women succumb who are left to expel the child unassisted. Therefore the prognosis is much more favorable in a prompt delivery than in one that has been delayed.

How the termination of the pregnancy shall be effected must be governed by the condition of the cervix, frequency of the convulsions, and depth of the coma. If the cervix is already dilated and there is no longer any contraindication to the use of forceps or version, rapid delivery is easily accomplished. Such cases occurring late in the stage of dilation have, as is well known, a relatively favorable prognosis. It is less promising when the convulsions appear before the cervix is sufficiently dilated. If the cervix is effaced but the external os remains undilated, metal or manual dilatation may suffice to effect quick delivery. If time is not a necessary factor, in multiparæ with old lacerations of the cervix, instrumental or manual dilatation might be hazardous; therefore in these cases rubber bags can be employed. The author recalls one such case in which an old tear of the cervix being felt to give way during manual dilatation, the method was promptly abandoned and a Voorhees bag substituted with success.

When the cervical canal is rigid and not unfolded, metal and manual dilatation, or, more correctly speaking, *divulsion*, of the cervix aggravates the eclamptic seizures and causes shock; deep cervical tears are not infrequent, and hæmorrhage and infection often complicate the situation. Therefore, we have in cases of intact cervices with menacing signs the operations of vaginal hysterotomy and abdominal Cæsarean section at our command. The former is indicated in cases occurring before the eighth month and the latter after that time.

Like many other innovations, vaginal Cæsarean section has been vehemently opposed as being an irrational and hazardous procedure, and even stigmatized as the prostitution of surgery; yet, in spite of the opposition, it is steadily growing in favor and is considered by many as the most important addition to obstetric technique in modern times.

Peterson [2] has collected 530 cases of eclampsia in which vaginal Cæsarean section was performed, with 124 deaths, or a mortality of 23 per cent. In this connection it might be stated that general statistics are not always infallible as to the merits of a measure in any particular case, depending as they do upon the environment, and the judgment and skill of many operators. Rather should we judge the measure and its possibilities from the results obtained by individual operators. For instance, in 33 cases of vaginal Cæsarean section for eclampsia, Veite had only one death, and Bumm had only one death in 40 consecutive cases. The operation has been performed 26 times in this city, by 5 operators, with 2 deaths, or less than 8 per cent.

The author [3] recently reported four cases of classical Cæsarean section for eclampsia successfully operated upon four or more times in this city; three times in one case by Dr. W. P. Carr and one case by Dr. Stone. All the children were delivered alive and three are still living. In reviewing the literature the author collected 116 cases, with a maternal mortality of 48.93 per cent and infant mortality of 39 per cent. At first glance this is not a convincing argument in favor of this method of intervention in eclampsia, but the final analysis shows that a very large percentage of the patients had been previously subjected to other methods of treatment, and many were practically

[2] Am. J. Obst. & Diseases Women & Children, 1911, lxiv, 1.

[3] Southern Surgical and Gynecological Transactions, 1911.

[1] Read in a Symposium on Eclampsia before the Medical Society of Georgetown University, November 9, 1912.

moribund before the operation was resorted to. If we compare the series of 53 cases from 1901, collected by myself, with the previous ones, we find that the death rate for the mothers has been reduced to 32.32 per cent and for the infant, 19.9 per cent. This steady improvement in the statistics has been due in a great measure to better technique, greater care in the selection of the cases, and prompt intervention.

Certainly with the knowledge gained and with wider experience, it is reasonable to expect that the mortality will, in appropriate cases, by the elective classical and vaginal Cæsarean section be still further reduced.

Lumbar narcosis has been practiced in eclampsia, but without success; likewise lumbar puncture, with subsequent aspirating of the cerebrospinal fluid.

Zangmeister [1] believes that eclampsia is a kind of reflex epilepsy and is the result of pressure from œdema of the brain, which is enormously increased during the strain of each labor pain and which he claims may be relieved by reducing the pressure through the agency of prompt trephining. Zangmeister had the courage of his convictions, and actually did the operation in three severe cases of eclampsia persisting after delivery, two of which patients recovered and the third died on the sixth day, although the eclampsia had long subsided. In the latter case the dura had been sutured again after the operation, and it is possible that the œdema recurred. Kosmak says this must be regarded as rather an extreme form of treatment, and may be classed with that which depends on a complete amputation of the breasts for the subsidence of the convulsions.

As to whether Edebohl's operation of decapsulation of the kidneys will extend its sphere of usefulness to eclampsia, it is not possible to form any definite conclusion from the available data. Of the ten cases on record, the decapsulation was followed by rapid recovery of six of the patients; in two cases no benefit was manifest, and in the remaining two improvement was probable, but not pronounced. In eight cases the women had been delivered before the operation, including one of the cases in which no influence was apparent from the operation. In the other cases the operation had been done before the evacuation of the uterus, the results being successful in only one of them.

Venesection is so seldom practiced nowadays in the treatment of eclampsia as to be almost regarded as a lost art, and yet in suitable cases it is one of the most valuable measures at our command in combating eclampsia. Where the blood pressure is high, with cyanosis, rapidly recurring convulsions, deepening coma, and threatened œdema of the lungs, it is particularly serviceable. Its beneficent effect was strikingly shown, where those indications were present, in a post-partal case seen recently in consultation with Dr. Wilson, and the author is thoroughly convinced that the blood letting was the principal means of saving the patient.

The author wishes to say a word of caution regarding anæsthesia. Chloroform, almost since its discovery, has been considered as one of the sheet-anchor remedies in eclampsia. An unfortunate experience in the loss of a case from late chloroform poisoning has taught me that it is an exceedingly dangerous remedy and that its value has been greatly overrated. Recent investigations have demonstrated that it produces lesions of the liver and other organs similar to those of eclampsia. Given at the time of the convulsion, when there is a tendency to asphyxiation, it increases the difficulty by interfering with the supply of oxygen, and, furthermore, it is a cardiac depressant. The author has for these reasons abandoned its use in obstetrical cases, and restricts the administration of the anæsthetic until the time of intervention, and gives ether.

Dr. Foote informs me that the two fatal local cases after vaginal Cæsarean section had received nitrous oxide anæsthesia. Since that time investigation by himself and Hamilton shows that the ammonia coefficient is increased in some cases with resulting acidosis; so, like chloroform, its use in eclampsia is contraindicated.

Of course, synchronously with the obstetrical or surgical termination of the pregnancy, eliminants and sedatives are to be employed, because the combined treatment yields the best results.

It must be borne in mind that we have as yet no specific treatment for eclampsia, and the method of intervention must be adapted to the exigencies of the individual case. In the presence of the severe types we are well-nigh hopeless. The graver forms comprise from 3 to 5 per cent of the cases in general, they are more frequent at different periods, and they may appear in groups. Such was our experience at Columbia Hospital. After having obtained for several years quite successful results, that is to say with a mortality of 10 to 15 per cent, these were followed by a series of cases in which the previously approved treatment absolutely failed, the mortality reaching 70 per cent. These malignant cases are frequently attended with few convulsions, coma quickly

[1] Quoted from Kosmak, Am. J. Obst. & Diseases Women & Children, 1912, lxv, 5.

supervening after the first seizure, accompanied by fever, jaundice, hæmaglobinuria, or suppression of urine, and they are rapidly fatal.

In conclusion, while the etiology of eclampsia is still unsolved, its clinical phenomena and pathology point to a probable intoxication of fœtal, maternal, or combined origin. Therefore, evacuation of the uterus, elimination, and sedation are the chief indications in the treatment. The sedatives are valuable for their tranquillizing influence while delivery is being promoted or effected by other direct measures. The result in a given case will depend upon the severity of the attack, the judgment and skill of the physician, and the rigid observance of asepsis. Essential to success is a well-thought-out plan of prompt but not overzealous procedure, based upon the various phases of the disease, combined with a knowledge of the *condition of the cervix and the changes it must undergo* before pregnancy can terminate or be terminated.

The author wishes to supplement this conclusion with the following "Don'ts":

Don't delay terminating the pregnancy after the onset of the first convulsion. The earlier the uterus is evacuated, the lower the maternal and fœtal mortality.

Don't treat the patient haphazardly, as the mortality and morbidity are exceedingly high under such conditions. Endeavor to choose the right method of operation in the first instance.

Don't give chloroform or nitrous oxide, as they both cause acidosis. Ether, while not free from objection, is the least harmful; but its administration should be restricted to the time of intervention.

Don't forcibly dilate an intact or rigid cervix. It is irrational and unjustifiable. Bear in mind the physiological and anatomical changes necessary to soften and unfold the cervix, and dilate the external os. The divulsion of the cervix in a few minutes by instrumental or manual methods — what Nature takes, under normal conditions, hours to do to preserve the integrity of the soft parts — is unscientific, dangerous, and brutal. It is in this class of cases that the cutting operations, when done primarily, give such excellent results. Vaginal hysterotomy is the operation of election up to the eighth month, and the abdominal Cæsarean section after that time; particularly when the child is of average size or has a weak fœtal heart beat, in cases of corpulency or when the cervix is high, in posterior positions.

If these "don'ts" be universally observed we will see a great reduction in the mortality and morbidity of eclampsia.

DILATATION OF TIGHT URETHRAL STRICTURES CAUSING RETENTION

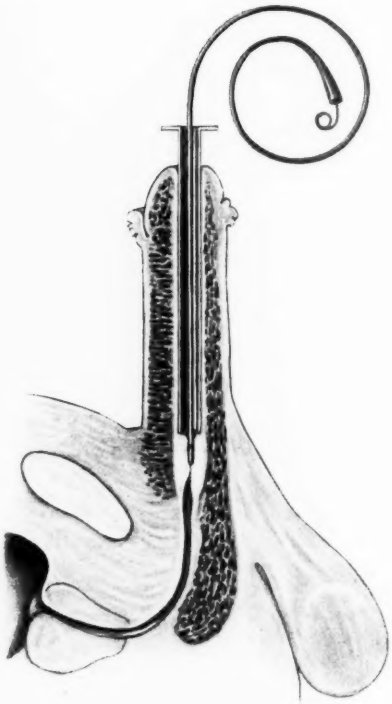
By W. S. SCHLEY, M. D., New York City

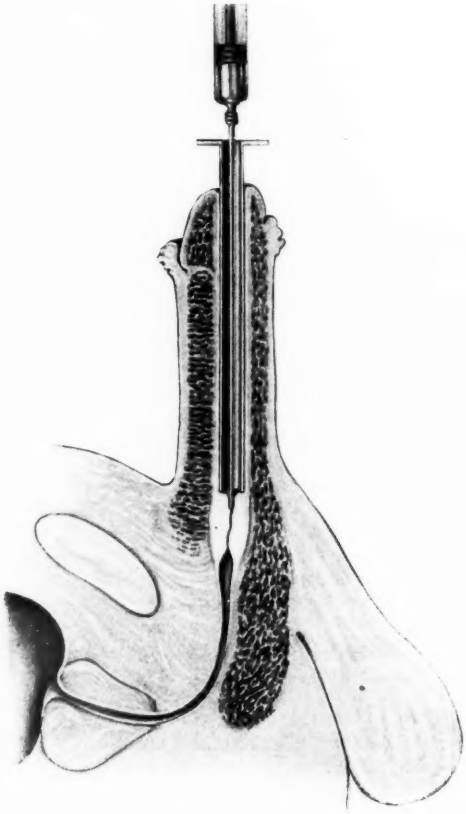
OCCASIONALLY, even with the aid of the endoscope it is impossible to pass a filiform through a tight urethral stricture which is causing retention, or, if not impossible, at least it is accomplished only after the expenditure of considerable time and labor and with the danger of urethral laceration. The injection of oil and the use of cocaine and adrenalin in the urethra are of great service, but they must come in direct contact with the strictured area.

The following method I employed for the first time nearly seven years ago, and with its aid some of the difficult strictures of the urethra may be passed and subsequently dilated without urethrotomy, external or internal. It has served extremely well in those strictures far enough forward to be instrumented with accuracy from the meatus.

An endoscope is passed to the site of the stricture, developing its orifice. A blunt pointed round-end needle of hypodermic type and 17 or 18 Brown & Sharpe gauge diameter is pressed against or as far in the orifice as extremely gentle pressure will allow, and a few drops of cocaine-adrenalin mixture introduced. In a few minutes it is usually possible to insert the needle very appreciably farther in. After it has entered 4 or 5 mm., a No. 5 F. woven ureteral catheter with taper end is substituted and injections made through this, advancing after each injection. The catheter is smooth, sufficiently flexible, especially the tip, and takes the irregularities in the stricture well. Ten or fifteen drops of the solution are usually sufficient. The case below is illustrative:

E. R., April 28, 1906. A man of 50 years of age had had a stricture of the urethra for over 15 years. He presented himself, with complete retention, having been unable to





void urine since forcing out a few drops in the early morning some hours before. Filiforms failed to pass. The endoscope showed a tight stricture beginning just below the penoscrotal junction. By moderate pressure on the instrument the orifice was developed more clearly as the mucosa was stretched from the center, but it was impossible to more than barely enter a filiform. A long medium fine blunt-end needle entered 2 or 3 mm. and a few drops of equal parts 1–1000 adrenalin and 4 per cent cocaine solution were injected. After the needle had passed about 5 mm. the ureteral catheter was used, and in a total of fifteen minutes' work it had passed to the bladder. The stricture proved to be of 3 cm. length. The following day it was more difficult to insert the catheter, and I regretted not having left a filiform in place. There was undoubtedly engorgement following the anæmia produced and the mechanical insult. On the third day, however, it was possible to pass a No. 8 F. elastic bougie, and a week later a No. 10 F. From that time on the dilatation was simple. Three months later a No. 25 F. sound passed smoothly.

After the first dilatation it is well to leave a filiform in the urethra if urethrotomy is not done. The latter operation may be done with the Maissonneuve or any of its modifications with or without an external urethrotomy if preferred, or an external urethrotomy done with the filiform as a guide, or the stricture reserved for dilatation later.

It is not the intention of this paper to go into the relative merits of dilatation or urethrotomy for these cases or retrograde passage of stricture, perineal or suprapubic, but to suggest a method of passing some of the difficult ones for the relief of retention or for a guide for urethrotomy.

TRANSACTIONS OF SOCIETIES

CHICAGO SURGICAL SOCIETY

REGULAR MEETING HELD NOVEMBER 3, 1911, THE PRESIDENT, DR. FREDERIC A. BESLEY, IN THE CHAIR

DR. E. C. RIEBEL read a paper entitled, "Rupture of the Diaphragm, and Positive Pressure (Meltzer's Insufflation)." See p. 133.

DISCUSSION

DR. H. M. RICHTER: Dr. Riebel, in his paper, opens up a number of phases of thoracic surgery for discussion. First, what class of cases require the use of a device for maintaining respiration; second, what apparatus should be used, and, third, which of the various types of artificial respiration should be used.

First, as to what cases require the artificial methods of maintaining respiration in thoracic surgery? For our purpose, we may consider the chest made up of two compartments, separated by a complete diaphragm, and each section capable of functionating independently of the other, either one functionating without the other and capable of maintaining life. Therefore, if the injury or the disease is such that one side of the chest only is interfered with, it would seem to me we immediately do away with all need of any type of artificial respiration. For instance, we may safely open one side of the chest for any purpose whatever; opening it through the diaphragm or through the chest wall would, of course, be equivalent. A rupture of the diaphragm, resulting in a hollow viscus of the abdomen passing up into the chest cavity, may be handled either by increasing the intrathoracic tension by any positive pressure device in use, or, more simply, by making an incision between two ribs and allowing air to enter the chest in that way. If in such a case of rupture of the diaphragm on one side the incision were made between two ribs, it would be difficult to maintain the abdominal viscera in the chest. They tend to slide back into the abdomen in the same way as in ordinary laparotomies. An incision made through the abdominal wall in a patient who is completely relaxed would not tend to allow the hollow viscera to escape through the abdominal incision. With the patient relaxed the viscera would remain within the abdomen.

Taking it for granted that we have occasion to use some method of artificial respiration and of maintaining life by it, then there are three types of apparatus to be considered in making our choice: the type of so called negative pressure apparatus devised by Sauerbruck; the various positive pressure types of apparatus, all of which work practically on the same principle; and thirdly, the method of Meltzer. If life can be maintained by getting air within the lung without making any respiratory movements, if the external respiratory movements are not essential to life, if their only object is to get air within the lungs, then it seems to me, the Meltzer apparatus is the ideal apparatus, because by passing a tube down the trachea to near the bifurcation and passing a continuous current of air through it we can obtain air in the lung where we want it. As a matter of fact, that has been done.

I saw some of Dr. Riebel's work, and I have personally used Meltzer's method, and there is no doubt at all but what it is a successful method. The so-called positive and negative pressure methods of maintaining artificial respiration are based upon the same mechanical principle; the positive pressure devices are simpler; Meltzer's method should displace both to a great extent.

The device of which I published a description a couple of years ago was a comparatively simple one for maintaining the lungs in distention and maintaining artificial respiration; but the Meltzer device has rendered it to a great extent unnecessary. If we need some method of maintaining respiration and of getting air into the lungs, the Meltzer method would appear to be the method to use.

Dr. Riebel spoke of using from forty to sixty millimeters of mercury with the Meltzer apparatus, and I think he meant with the chest opened. The tension within the lungs may be raised to a

great height, provided the chest is closed. A man in playing such an instrument as a horn can raise the tension within his chest to a considerable height. A man descending beneath the surface of the water raises the tension fifteen pounds for every thirty-two feet he descends. But the lungs will not stand a tension of more than ten or fifteen millimeters of mercury with the chest opened, because the lungs are so delicate that with that amount of tension, without protection of the chest wall, they would balloon up indefinitely. A pressure of six or eight millimeters within the lung with the chest opened will maintain the lungs in the ordinary sized dog at the normal physiological extent of distention. A pressure of ten to twelve millimeters of mercury will blow the lungs out of the chest. We are making an error in our deductions from experimental work on dogs, in that we are forgetting that the dog's chest for experimental purposes is practically a single cavity instead of a double cavity. The dog's mediastinal septum is so thin and movable that, if we open one side of the chest wall, it practically allows collapse of both lungs. That does not apply to human beings, except to young infants.

Dr. Arthur Dean Bevan: Dr. Richter's discussion is a very able one and particularly valuable, because he has done a good deal of work along this line, and I think the conclusions he has arrived at are absolutely correct. You all know that a lot of money has been spent in connection with this work. For example, one New York surgeon has had a special operating room constructed at the expense of many thousands of dollars; and then when Meltzer introduced his simple apparatus, this surgeon naturally criticised the simple Meltzer apparatus because he had already spent some twenty-five thousand dollars for installing an elaborate apparatus which meant that amount of money thrown away if Meltzer's apparatus was as efficient. There has been a whole lot of work done along this line. But just as Dr. Richter has pointed out, one lung will work and carry on the function of the body just as one kidney will do. That point has been shown by a lot of very good work.

Dr. John Young Brown, of St. Louis, read a paper before the Illinois State Medical Society a few years ago, in which he reported some twelve or fourteen cases of rupture of the diaphragm, where he opened the chest wall and repaired the rupture through the transthoracic route, showing definitely that this work could be done without danger. He only lost two of his cases. He showed that this work can be done very well without any elaborate apparatus.

Dr. Wm. J. Mayo often does his kidney work by resecting the twelfth rib. He has told me several times that in a number of cases he has opened the pleural cavity in resecting the twelfth rib in his kidney work, although he has never had any trouble whatever. He has made immediate closure. Personally, I have had a number of experiences of opening the pleura. I have always had the fear of doing it and of making artificial pneumothorax. I have done that a number of times, but with no serious trouble unless infection follows. I am thoroughly convinced we can take the position which Dr. Richter has so well laid down, that if one lung is normal, and you are operating on the other lung, you do not need all these complicated apparatuses; that you can go ahead and operate under proper anæsthesia, and if you do not get infection, you can do a great deal of work on that side without any trouble. Take the work that Dr. John R. McDill[1] has done of transthoracic opening of liver abscesses. This is a very good scheme. In the McDill scheme of exposing the upper surface of the liver by the transthoracic route, he takes particular care to try and avoid opening the pleural cavity, but you may be sure that he sometimes has a collapsed lung. Suppose he wants to attack the subphrenic space or upper surface of the liver: he will make a concave incision, resecting one or two ribs subperiosteally; then he will have his assistant hold his fingers on the flaccid chest wall from which the ribs have been removed, and push the flaccid wall against the diaphragm; then he cuts through the chest wall and cuts through the diaphragm; then he will sew up the chest wall and diaphragm together, whip them up with a continuous suture or whipping suture so as to hold the chest wall and diaphragm together and close the pleural cavity so that you can open the subphrenic or abscess of the liver or do any operation in that way. You may be sure, in the hundred or more cases that John McDill has operated upon in that way, in many of them he has had collapse of the lung. He had immediate closure of the pleural cavity with a given suture line, and, as a rule, no resulting infection. Of course, occasionally there is an infection; I should not hesitate at all in a case of rupture of the diaphragm to-day, where the individual had any trouble with the other lung, to attack the lesion through the transthoracic route without any special form of pressure apparatus, and with a good anæsthetic sew it up just as I would an ordinary hernia, and then make a clean closure of the thoracic wound,

[1]McDill, John R. Surg., Gynec. & Obst., 1911, xiii, 523.

with the expectation that the air in the chest would be taken care of within a short time and the interference with the lung function would be of little moment in the case, provided I had succeeded in excluding any infection.

DR. E. WYLLYS ANDREWS: This paper and the discussion on it have taken a direction in which I have made something of a hobby of late years, since not long ago I had five cases of operative treatment of wounds of the diaphragm in one year. One point which has been emphasized is that opening the pleural cavity may be a perfectly harmless thing. The other is the necessity of treating these diaphragm lesions through the chest and not through the peritoneum. We used to hear from Willard's experiments and those of others of rushing cool air into the pleura, producing shock and collapse and dyspnœa. It does not do anything of the kind. I have done it accidentally, and have been foolishly terrified by the hissing sound of a little air entering when resecting a tuberculous rib, or operating upon a kidney, or in trying to reach an abscess of the liver. Having found that we were unnecessarily alarmed over this, we have gone a little farther and let air in deliberately with no bad result. Within a year I have freely incised the chest, taken out four or five ribs, and removed a carcinoma of the mamma. We used to think this almost as dangerous as letting air into the jugular vein. Opening the pleural cavity does not only not endanger life, but I have seen with my own eyes several instances in which the lung did not collapse at all. I believe the lung can lie exposed against a large lesion of the side of the chest and remain perfectly expanded and continue to expand with all the suction pressure of the chest and diaphragm removed, or at least, the suction pressure of the chest.

I had a case, about a year ago, in which the diaphragm was ruptured by internal pressure from a traumatic hernia, the colon being pushed up through it, and, at the same time, the ribs were detached, four in number, from the sternum in front. I tried to reduce the colon and suture the wound and the diaphragm through the chest, but during that operation and the time required to make the replacement, the lung was actively expanding and pushing itself out into the open area just as if it were being blown up with a positive bellows. I cannot understand that, but I saw it. Of course, we would infer the reason of the lung expanding is suction of the chest wall by the vacuum about the lung, just as if it were tightly agglutinated to the ribs and diaphragm. But in at least two instances, and I think in others, I have seen the lung in the wounded chest with a comparatively large hole through the chest wall and skin actively expanding itself as if the chest wall were not open at all.

To repair a wound of the diaphragm, the transthoracic route is the proper one. I think it is only fair to insist on it by way of warning those whose first impulse is to attack such a lesion through the peritoneum. We are accustomed to working in this cavity, and we first think it is easy to suture the diaphragm from below. The moment you have a large experience with these cases and follow up the literature, you will find by your own experience and by the uniform testimony of others who have tried it, that it is the most difficult operation you can possibly attempt. It is most inaccessible and tedious to reach the lower surface of the diaphragm. On the other hand, if you open one side of the chest freely to expose the diaphragm, there is practically no distance from the ribs inward. It is a dome-shaped affair, scarcely half an inch away from outer chest wall at the seventh to tenth rib. I will go a step further and say that we should often do a laparotomy transpleurally, say for a liver abscess or growth, or for operations on the cardial orifice of the stomach. I give a very fair drawing of this technique (taken from Cranwell of Rio Janeiro) in my article in Vol. VII, Bryant and Buck's Surgery. Some fine plates and descriptions are also to be found in Sauerbruck's new book, "Thoraxchirurgie."

DR. COLEMAN G. BUFORD: After one has had considerable experience in chest work, he finds that it is not necessary to adopt complicated methods in the large majority of troubles like that in question. It does not take long to ascertain how much real work can be done through the chest wall, when the lung is already collapsed. This collapse can be brought about through a simple stab wound of the thorax or by resection of the ribs with little if any resultant difficulty in breathing. Each of us has seen how little disturbance in this connection has been caused, when we have been called upon to drain one side of the chest for empyema and how much available operative space there is in the thorax. We may go still further and recall the experience of others, if not within our own experience, who have even drained both sides of the thorax for empyema with favorable outcomes. It therefore seems to me quite rational to resect the chest wall and use this as the operative field in cases where the diaphragm has been ruptured and the viscera have prolapsed into the thorax. I feel as Dr. Andrews does about it, that this is the most accessible

field for repair of the diaphragm. It occurs to me this moment that there might be occasions when one would want to repair the diaphragm on one side and immediately expand the lung on that side to facilitate breathing and follow it by repair of wounds in the other thoracic cavity. In this connection, I recall an experience I had a short time ago. I resected the chest wall for secondary carcinoma. Dr. Bevan saw this case with me. I took out parts of two ribs. In doing this I easily teased off the pleura, but while suturing the skin, the pleura was punctured and the lung collapsed. The opening immediately gaped instead of closing. The pleura was so thin I could not suture it. The skin and cellular tissue were sutured tightly, thus completely closing the wound. I now put a trochar in the chest wall, aspirating all of the air that I could, which permitted of immediate lung expansion to the extent that the lower posterior border was about two fingers' breadth higher than it should be. On the third day the lung boundary was normal. This plan of management might be more generally practiced than it is in wounds of the thorax, permitting of immediate closure.

DR. L. L. MCARTHUR: I would like to say, that possibly there is a misconception in regard to Dr. Riebel's statement, that the pressure within the lung was raised from forty to sixty millimeters of mercury in using the Meltzer apparatus. That pressure may be shown in the manometer, but the catheter, not filling the entire trachea, permits air to escape, so manometer does not measure the actual pressure within the bronchi themselves. I, too, have shown to this society a case of resection of the chest wall en bloc for carcinoma, in which I proceeded boldly to resect an area in the chest wall involving two ribs, the pericardium being brought distinctly in view and the lung collapsed, then suturing more snugly than usual the temporarily reflected skin and superficial tissues. I aspirated the chest cavity immediately of the air left there, using a protected needle (a needle that has a sharp point for penetration, but as soon as it enters the chest cavity is covered with a rounded point that prevents injury to the lungs). I immediately succeeded in expanding the lung to its full amount. We could feel it against the needle low down in the chest cavity. The aid which comes from increasing the pressure in the lungs, by any one of the positive pressure apparatuses, is particularly great and efficient when it comes to suture of the lung substance, or suture of the lung to the chest wall, as is sometimes desirable when the lung is later, at a second step, to be penetrated.

DR. RIEBEL (closing): There is one fact I tried to point out, namely, that so many investigators differ in their conception of a pneumothorax. Collapse of the lung alone is not pneumothorax. That is the reason why I described my case in the human resembling an experiment; the chest wall was held open with two retractors and there was no disturbance at all. An internal or tension pneumothorax, on the other hand, is the most dangerous form we have, and prolapse of the organs containing air into the chest cavity is equivalent to that, causing derangement of the relations within the chest cavity and serious disturbances of internal respiration.

I looked over the article of Dr. Brown which Dr. Bevan referred to, and, as I understood it, he did not cite any subcutaneous ruptures. His cases were all instances of stab wounds with wounds of the diaphragm.

DR. BEVAN: They were all traumatic.

DR. RIEBEL: They were all open wounds, but mine was a subcutaneous rupture of the diaphragm, and in a case like that, with marked muscular defense, the possibility of an injury of an abdominal organ would have to be considered. I find in the literature a good many cases of stab wounds of the chest, where finally laparotomy had to be done to reduce the prolapse which was not possible from above.

It is too late to answer all the points brought out by Dr. Richter and to go into the differences between the value of Meltzer's positive pressure and that of Brauer; suffice it to say it is of entirely different character. The positive pressure Dr. Richter has been working with is static in character, whereas Meltzer's is dynamic. Regarding pressure differences: that is a mistake. I did not mention sixty. The highest pressure I used was forty, and then, of course, it was that only at the manometer.

WASHINGTON SURGICAL SOCIETY

REGULAR MEETING HELD MAY 17, 1912, WITH THE PRESIDENT, DR. CARR, IN THE CHAIR

DR. FOWLER reported four cases, with specimens, of suprapubic prostatectomy, illustrating the good results of this method in selected cases having large and medium sized adenomatous prostates. There is no danger to the rectum and the ejaculatory ducts are preserved. After opening the bladder, incision into the prostatic mucosa is not necessary, as a satisfactory plane of cleavage can be found in the prostatic urethra. It is not necessary to introduce the hand into the bladder, but it is of great assistance to keep a finger in the rectum. He believes in packing the cavity with gauze, as being safer and more surgical than depending on hot irrigations. Packing should be wholly or partly removed in twenty-four hours to prevent possible necrosis of rectal wall. Appropriate pre- and post-operative treatment is of great importance in these cases.

DR. BALLOCH noted that nothing was said of prior cystoscopy in these cases, which by some is considered so important. He is glad to see that the suprapubic operation is gaining in favor, as he thinks it less dangerous, though not practicable in all cases. It is interesting to note the method of commencing enucleation by the way of the prostatic urethra.

DR. HAGNER thinks cystoscopy advisable as a routine, as methods of procedure may be altered thereby. A few years ago he used the perineal route exclusively, though he now agrees that certain cases are best treated suprapubically; it is practically impossible, however, to remove a small hard prostate from above. He advises in badly infected bladders to operate in two stages, by draining the bladder for a week or two, using nearly continuous irrigation. He always packs the wound.

DR. FOWLER said that in these particular cases cystoscopy was not necessary, though he uses it as a rule. He agreed as to the advisability of a two-stage operation in bad cases. Many large prostates are not true cases of hypertrophy, but are adenomata, the prostate itself being pushed aside. By the procedure described, the ejaculatory ducts are preserved and in the four cases mentioned sexual power was retained.

DR. TRUMAN ABBE read the paper of the evening entitled, "How can we improve the results of our operations for cancer?" (See p. 185).

In discussion, DR. CARR said the subject was timely, as cancer is unquestionably on the increase all over the world; it is possible that modern methods of life, with overeating and overwork, may cause a precancerous condition. Trauma may be an immediate cause, but only in a case with the already developed tendency. One reason for incomplete operations is the leaving of too much skin, especially in breast cancer, as pointed out especially by Halstead. He has always freely used bichloride in these operations, with a view to destroying detached cancer cells. The great question is that of operability, and he thinks we should hesitate to pronounce a case hopeless. There is a great field for the education of the general practitioner in the diagnosis and prognosis of cancer.

DR. G. BROWN MILLER mentioned the opinion, as to cancer of the uterus, of the German authority, Krönig, who deplores the skepticism as to cure in these cases. He operates, or tries to operate, 83 per cent of these cases, and while he loses 20 per cent of the cases, yet at the end of five years he had a greater percentage of cures than any other surgeon. In all cases presented 25 per cent or 30 per cent of cases were cured. Dr. Miller had always believed a wide area of involvement, with fixation, as hopeless, but now believes in laparotomy to see if fixation is simple or cancerous. He, too, thinks much can be done in educating both the profession and the public.

DR. HAGNER said that many bladder and prostate cases had had symptoms a long time before any positive attempts at diagnosis were made, whereas the only hope was in a very early interference. If a radical operation cannot be done, it is probably best to do nothing at all, as interference seems only to accelerate the growth.

DR. THOMAS CHARLES MARTIN urged the importance of proctoscopic examination of every marked case of constipation or diarrhœa or both. The usual finding is a more or less irregular mass, above the levator, which may or may not bleed. An apparent mass, due to rectitis with local induration, may disappear on dilatation.

DR. FOWLER said that many cases of prostatic hypertrophy showed areas of malignant degeneration, usually situated deeply in the gland and removed with it, especially in the hard scirrhotic type. He agrees with Dr. Hagner as to stirring up a hopeless tumor, whose growth is usually slow. As an interesting fact, he had never seen

cancer of the penis where there had not been an adherent prepuce

DR. ABBE in closing said he wished to emphasize the importance of education in the cancer problem, education had been of such value in tuberculosis and other health problems, and that the public is now in a receptive mood toward trustworthy information on all such matters; he hoped that a concerted effort would soon be made in that direction.

CORRESPONDENCE

GUNSHOT WOUNDS OF THE CHINESE WAR

The total casualties in the recent civil war in China may never be determined. The Chinese leaders say they do not know. The foreign doctors and others who did Red Cross work at Hankow estimate that those killed number 10,000. These men did field work and manned the base hospitals. Moreover, thousands of the dead had to be buried under foreign supervision, and so this estimate for Hankow may be taken as quite near the truth.

But how many wounded there were it would be still harder to say. One doctor of the Shanghai Red Cross Society who spent a short time at Hankow estimated the number of wounded at 15,000. But members of the local Red Cross Association who were at work from the beginning of the war till the close say that it is impossible to name any definite number. About 10,000 wounded were treated in foreign hospitals in Hankow, Hanyang and Wuchang.

Military equipment. Both armies were equipped along modern lines. The nucleus of the Imperial army was built up by Yuan Shi Kai over ten years ago. The men had modern rifles, field guns, and large cannon, and they were trained in their use. They were disciplined and there was no needless exposure to gun-fire in battle. Their uniforms and first aid pockets were ample compared with those of their opponents, the Republicans. The Imperialists used a 27 mm. rifle made in Shanghai and Tientsin built after Mauser and Mannlicher models. The length of the bullet was something over 3 cm. It was slightly longer than that used by the revolutionists, and it had a truer nose. In their machine guns, they used .32 cal. bullets, sharp and conical pointed. The first aid packet contained gauze, adhesive, and one triangular bandage with diagrams showing its use printed on the wrapper.

In comparison, the revolutionary army was hastily gathered together. And, while far larger in number, the soldiers were poorly trained in military tactics and in the use of guns. They received more wounds and their firing was less effective than their opponents'. "One dead Imp means two dead Reps," was a common estimate made. The revolutionists used a model 88 Mauser rifle of .312 caliber. The bullets were thick, short, and blunt. Five hundred, 45–70 rifles using lead bullets were issued to the revolutionists. Bullets of hard wood, about 4 cm. long, stained indigo, and mounted in cartridges having a full charge of powder were sometimes found on, but never in, the republican soldiers. They were not provided with first aid packets. Their personal equipment consisted of what they could get.

Field work. The field workers were supplied with bandages, gauze, splints, morphine, and iodine. A five per cent solution of iodine was applied to all wounds. In from one to twelve hours, and sometimes longer, most of the patients were carried off the battlefield and carried into the base hospitals. Coolies were used to transport the wounded to and again from the Red Cross launches which were used to convey the wounded from the several river points to the base hospitals in the foreign concessions of Hankow. The doctor in charge of the field work had opportunity to observe also the work in the base hospitals, and he found no bad results accruing from iodine, even in cases where considerable absorption undoubtedly took place, as in shrapnel wounds. The splendid results from a free use of iodine, both in first aid work on the battlefield and in the hospitals, made many of the Red Cross doctors stanch preachers of the gospel of iodine.

Base hospitals. Fortunately, in Hankow there are a number of large mission hospitals, also an international hospital, whose doors were thrown

open to the wounded soldiers of both sides indiscriminately. A large cathedral was also used for a time for minor cases. The medical missionaries assumed a large share of the work, especially through an efficient local Red Cross organization, which enjoyed the confidence of both armies. In addition, there were the private practitioners who gave themselves untiringly, as did a number of doctors from the various gunboats of different nationalities. At the height of the fighting there were eight permanent or temporary hospitals at work. In some were soldiers of both armies.

Kinds of wounds. High velocity rifle bullet wounds were the most frequent. Shrapnel wounds were more frequent among the Republican ranks than the Imperialist. Because of the manner in which they were inflicted, bayonet wounds were fatal and almost never brought into the base hospitals. The same may be said of those wounds made by short knives in which the jugular vein and the common carotid artery were cut. There were quite a number wounded in the back, who, because of poor training and discipline, were shot accidentally by excited comrades in the rear.

Wounds clinically. The rifle bullet wounds, generally speaking, were of three distinct types. The damage done by the sharply pointed machine gun bullets was small unless a vital organ was affected. Infected material was seldom carried in. The openings through the skin were remarkably small. The wounds usually were clean. Many healed by first intention. The regulation rifle bullet of the Imperialist equipment did greater damage. But the worst wounds of all were those inflicted by the blunt-nosed, thick-bodied bullets of the Revolutionists. Clothing was more often carried in. The holes through the skin were larger. There was a more extensive mutilation of the soft tissues. When bone was involved it was usually comminuted or crushed, with small fragments lying in the tissues beyond. The wounds were more frequently infected, and the cases did not do so well, no matter where they were hit.

Infection. There were a number of predisposing causes leading to infection: (a) Cleanliness on the part of the soldiers was exceptional, owing to the class of men who are always the first to enlist. Even if an attempt had been made to enforce personal cleanliness and other sanitary measures, the cold weather and general lack of discipline would have made such a condition impossible. (b) Clothing was more often dirty than clean. Some of the more fortunate soldiers had on from three to seven layers of it. As many new uniforms as possible were issued by both armies, but there were thousands of men who wore their own clothes, which had seen months, and perhaps years, of service, with the result that there were both ancient and modern filth waiting to be carried into the wounds. (c) Delayed transmission was a third factor. The revolutionists were more helpless in this respect than the Imperialists. When it came to fighting close to Hankow, both sides owe much to the work of foreigners residing in Hankow, who had the wounded taken off the field to where prompt and adequate attention could be given them. Of course, there were many shot miles from Hankow. Interesting cases came in days after they had been shot. The skin wounds had closed, and there had resulted extensive retention of pus, which had burrowed along the fascial sheaths. The Revolutionists had no field or ambulance corps. Both sides abused the Red Cross badge and were careless about shooting when the wounded were being taken off the field. With Imperial soldiers, where an amputation was called for at once, it was necessary to get the consent of the company and division commanders before the operation was undertaken.

Treatment. A few comments on the usual treatment may be of interest.

There were no attempts at any sort of probing where the bullet was deeply buried and no operation was indicated. Tincture of iodine dressings were applied.

Compound fractures were opened and drained as soon as possible. Normal salt or weak iodine solutions were used for irrigation.

There was some gangrene in cases where we played a waiting game. Dry gangrene usually cleared up nicely. The few cases of moist gangrene caused much trouble.

Few abdominal wounds developed peritonitis when left alone, usually in those cases where the patient had been without much food for three or four days. Because of the uncertainty of asepsis, even under the conditions there present, the abdomen was left alone. Many cases, however, had retention of the bladder, which was relieved suprapubically as a last resort.

In bullet wounds through the chest, the white of a raw egg was drawn up into a syringe and without further preparation injected into the wound.

There were three cases shot through the heart that got well. In a number of others, the diagnosis was not fully established.

This was the star case of the war: An Imperial soldier got in the way of his own machine gun

and was wounded in twenty places. He was shot through the jaw, the shoulder, the abdomen, the femur without a fracture, and the heart. The patient lived. W. W. PETERS.

Kiukiang, China.

To the Editor: The undersigned is very greatly interested in the subject of "Pregnancy after Oöpherectomy," and would appreciate certain information from readers of your journal who have had cases of this kind, and care to favor him with an account of the same. The facts desired involve the question of the relief of sterility following this operation, the character of the labor where pregnancy has occurred, the indications for removal of the ovary, the pathological condition of the same, an account of any other operations done at the same time, the character of the menstrual period subsequent to the operation, the date of birth of subsequent children, and their sex.

A blank form has been prepared which embodies these questions and which will be forwarded in reply to a post-card request addressed to the undersigned.

Yours very truly,

GEO. W. KOSMAK, M. D.

23 East 93d Street, New York City.

Dr. Franklin H. Martin,

Dear Doctor: You will be interested to know that Gauss of Freiburg has just sent me his book of 332 pages, covering 200 cases. Is there any place in your journal where a footnote could be put in to this effect, and as an answer to a number of inquiries that have come to me concerning my article, to-wit: "The Last Word on the X-ray in Gynecology." The new book by Prof. C. J. Gauss and Dr. H. Lembcke is "Röntgentiefentherapie, ihre theoretischen Grundlagen, ihre präktische Anwendung und ihre klinischen Erfolge an der Freiburger Universitäts Frauenklinik;" published by Urban & Schwarzenberg, Berlin, and Vienna; pp. 332, price, 15 marks. In the trip of the American Gynecological Club, the work in this clinic was more advanced than any that was seen.

ROBT. L. DICKINSON.

BOOKS RECEIVED

TEXT-BOOK OF GENERAL AND SPECIAL PATHOLOGY. By Henry T. Brooks. Philadelphia: F. A. Davis Co., 1912.

ZUR KENNTNIS DES UTERUSKARZINOMS. By J. Schottlaender and F. Kermanner. Berlin: S. Karger, 1912.

THE PRACTICE OF OBSTETRICS. Fourth Edition, Revised. By J. Clifton Edgar, M. D. Philadelphia: P. Blakiston's Son & Co., 1912.

A SYSTEM OF SURGERY. Vols. I and II. By C. C. Choyce, B. Sc., M. D., F. R. C. S. London and New York: Funk & Wagnalls Co., 1912.

THE PRACTICE OF DENTISTRY. By Leo Greenbaum, M. D., D. D. S., and Max Greenbaum, D. D. S. New York: D. Appleton & Co., 1912.

ANÆSTHETICS AND THEIR ADMINISTRATION, Fourth Edition. By Sir Frederick W. Hewitt, M. V. O., M. A., M. D. London: Macmillan & Co., Ltd., 1912.

THE SURGICAL CLINICS OF JOHN B. MURPHY, M. D., Mercy Hospital, Chicago. Philadelphia: W. B. Saunders Co., 1912.

HEALTH AND LONGEVITY THROUGH RATIONAL DIET. By Arnold Lorand, M. D. Philadelphia: F. A. Davis Co., 1913.

GENITO-URINARY DISEASES AND SYPHILIS. Third Edition, Revised. By Henry H. Morton, M. D. Philadelphia: F. A. Davis Co., 1912.

OBSTETRICS. Vol. V, Practical Medicine Series. By Joseph B. De Lee, A. M., M. D. Chicago: The Year Book Publishers, 1912.

FOOD IN HEALTH AND DISEASE. Second Edition. By Nathan S. Davis, Jr., A. M., M. D. Philadelphia: P. Blakiston's Son & Co., 1912.

SKIN GRAFTING. By Leonard Freeman, B. S., M. A., M. D. St. Louis: The C. V. Mosby Company, 1912.

ARTERIOSCLEROSIS. By Louis M. Warfield, M. D. St. Louis: The C. V. Mosby Company, 1912.

THE COURSE OF OPERATIVE SURGERY. By Prof. Dr. Victor Schmieden. Translated by Arthur Turnbull, M.D. New York: William Wood & Co., 1912.

COLLECTED PAPERS BY THE STAFF OF ST. MARY'S HOSPITAL — MAYO CLINIC — 1911. Philadelphia: W. B. Saunders Co., 1912.

ANALYTICAL AND DIFFERENTIAL DIAGNOSIS OF THE DISEASES OF THE NERVOUS SYSTEM. By Henry Hun, M. D. Troy, New York: The Southworth Company, 1912.

BOOK REVIEWS

A Cyclopedia of American Medical Biography. From 1610 to 1910. By Howard A. Kelly, M. D. Philadelphia and London: W. B. Saunders Co., 1912.

The idea of the biography is to be commended and is but another illustration of the versatile genius of its distinguished author. The work is in two volumes and biographies of over twelve hundred noteworthy figures in medicine are included. The details of such a work of necessity must be entrusted to many associates, and there is no doubt that the second edition will contain many important additions made necessary by the omissions in the present work.

The following men throughout the country have collaborated with the author in securing the material presented in the edition and have assumed the responsibility of gathering together the biographical sketches of the men from the portions of the country which they represent:

F. R. Packard and H. A. Kelly, Pennsylvania; J. A. Spalding, Maine; H. A. Kelly, New York; C. S. Caverly, Vermont; I. J. Prouty, New Hampshire; W. L. Burrage, Massachusetts; W. R. Steiner, Connecticut and Rhode Island; E. F. Cordell, Maryland; A. Robin, Delaware; R. M. Slaughter, Virginia and West Virginia; H. A. Royster, North Carolina; R. Wilson, Jr., South Carolina; J. B. Baird, Georgia; J. S. Helms, Florida; S. D. Lamb, Washington, D. C.; B. Foster, Minnesota; C. S. Sheldon, Wisconsin; L. Connor, Michigan; E. W. Andrews, Illinois; H. E. Handerson and A. G. Drury, Ohio; A. Schachner, Kentucky; A. H. Cordier, Kansas; H. W. Orr, Nebraska; J. Halpenny, Manitoba and Northwest Territory; A. B. Atherton, New Brunswick; A. McPhail, Quebec; S. R. Jenkins, Prince Edward Island; Donald A. Campbell, Nova Scotia; Oswald M. Jones, British Columbia; L. G. Le Bœuf and Rudolph Matas, Louisiana; G. M. Decherd, Texas; G. M. Kober and R. C. Coffey, Washington and Oregon; J. M. Taylor, Idaho; W. R. Tipton, New Mexico; W. B. Ewing, Utah; G. H. Kress, California; N. A. Powell, Ontario.

Diseases of Women: A Practical Text-Book. By Arthur H. N. Lewers, M. D. London and New York: Paul B. Hoeber, 1912.

In offering this new edition of a work long well known and popular in the British Isles, the publishers have presented it in improved form, the size of the volume having been considerably enlarged. Thus, while the author has rewritten many chapters and added much new matter, the entire work having undergone revision, even to the illustrations, there has been no appreciable increase in the number of pages. Throughout, the author adheres to his original purpose of offering the practitioner and student a text essentially practical. Therefore the clinical features of the volume have been retained, and from this point of view the arrangement is unaltered. As in previous editions, too, numerous cases are detailed in the text for the purpose of illustrating points where emphasis is desired. Two short appendices have been added — one a note on the systematic treatment of nerve prostration and hysteria wherein the Weir Mitchell treatment is described, the other a short discussion of coccygodynia.

A full description of the Wertheim radical operation for uterine cancer is one of the additions, and the section devoted to fibroid tumors has been largely amplified. Both the Webster and the Dudley operation for shortening the round ligaments is offered, as is a modification of the original Tait "flap-splitting" procedure for perineal relaxation. Dudley is drawn on again for his anterior vaginal wall operation in cystocele with urinary incontinence, and for his plate illustrating the menstrual cycle, which is too diagrammatic. In closing up the abdominal wall after laparotomy the author imbricates the fascial layers, as is excellently described by a colored plate. Cervical "erosion" is ably set forth, but, unlike other English authors, Lewers regards it as of relatively little importance, and does not mention it in treating of the etiology of carcinoma. No effort is made to reclassify those conditions enrolled under the title of "endometritis," and curettage remains as the operative treatment.

Illustrations are profuse and for the most part excellent. Particularly helpful are the plates in black and white and in colors. Unfortunately the microphotographs disclose the fault usually found in such illustrations, that of loss of definition in the reproduction. The imprint is excellent and, taken altogether, this new edition more than justifies the author's aim to provide a practical text.

Carey Culbertson.

Tumors of the Jaws. By Charles Locke Scudder, M. D. Philadelphia and London: W. B. Saunders Co., 1912.

On reading this book one must be impressed with the desirability of the monograph as a means of presenting such subjects.

Tumors of the jaws and mouth have not in the past received the attention that their importance merits, and no single publication has so fully and satisfactorily covered the field as does this book.

The value of the volume is added to by an article on "Leontiasis ossea" by Dr. Allen B. Kanavel, of Chicago.

The author very properly emphasizes the importance of early diagnosis in new growths of the jaws, in order that mutilating surgery may not be necessary and life conserved. One can find little in the book to criticise and much to commend. It is questionable whether the term epulis should be retained; however, the author has plenty of precedent for its use. Epulis means upon the gum, and when used to designate a connective tissue growth springing from the peridental membrane or from the periosteum, is misleading. The author speaks of ulcerated teeth, meaning abscessed teeth. This misnomer is borrowed from the laity and should not be employed. These minor matters are so insignificant that they should scarcely be noted. The illustrations are numerous and excellent, adding much to the value of the publication. The type, paper and general makeup is the very best. The profession will profit much through Dr. Scudder's contribution to a most important subject.

THOMAS L. GILMER.

BRAIN AND SPINAL CORD. By Dr. Med. Emil Villiger; translated by George A. Piersol, M. D., Sc. D. Philadelphia and London: J. B. Lippincott Co., 1912.

In translating Dr. Villiger's "Brain and Spinal Cord" so that it becomes accessible to American medical students, Dr. Piersol should have the thanks of all those who have to do with the teaching of this subject. The clearness of Dr. Villiger's text and the conciseness with which he states the abstruse facts in connection with the anatomy of the brain and the spinal cord have made it a favorite volume. In the translation of this third edition Dr. Piersol has been content to give us the original with but few changes.

To those who are not familiar with this treatise, it will be of interest to know that it is divided into three parts: First, morphology, dealing with the anatomy of the various portions of the brain and spinal cord in general; second, discussions of the various fiber tracts; and third, serial sections of the brain-stem. The book is to be recommended particularly because of the extraordinarily valuable pictures with which it is illustrated. The graphic representation of the courses pursued by the fiber tracts makes the subject so clear that one hardly needs to read the text if he is at all familiar with the general facts.

To the student the book is especially valuable, because by means of these valuable pictures he is able to follow the subject, which at best is very difficult of understanding; and to the practitioner a simple review of the pictures will be sufficient to refresh his memory as to these facts.

All told, the book makes a volume of over 280 pages, and is a credit both to the translator and the publisher.

LATERAL CURVATURE OF THE SPINE AND ROUND SHOULDERS. By Robt. W. Lovett, M. D. Philadelphia: P. Blakiston's Son & Co., 1912.

The second edition of this little work, revised and with a new chapter on "The Relation of School Life to Scoliosis," is the most complete monograph on the subject in English. The author has been doing original work in the pathology, mechanics, and treatment of scoliosis for more than a decade, and has embodied the results of his studies and experiences, as well as the valuable contributions to the subject by others, in a very readable little book. It should be of value and interest to all orthopedic surgeons and others who undertake the treatment of spinal deformities.

J. L. PORTER.

A SYSTEM OF TREATMENT BY MANY WRITERS. Vols. I–II of General Medicine and Surgery. Edited by Arthur Latham, M. A., M. D., and T. Crisp, M. B., B. S. New York: The Macmillan Company, 1912.

The idea of having works which consider disease from the standpoint of treatment seems to be growing in force, the demand coming from the busy general practitioner, who wishes to rush direct to the treatment of some disease without referring to the symptoms, pathology, or other items of the complex picture. This may be all right, and perhaps it will familiarize men with the newer modes of treatment, but to me it seems somewhat illogical. So we wish to consider these volumes from the quality of what they offer rather than any particular belief we may have in the correctness of the idea.

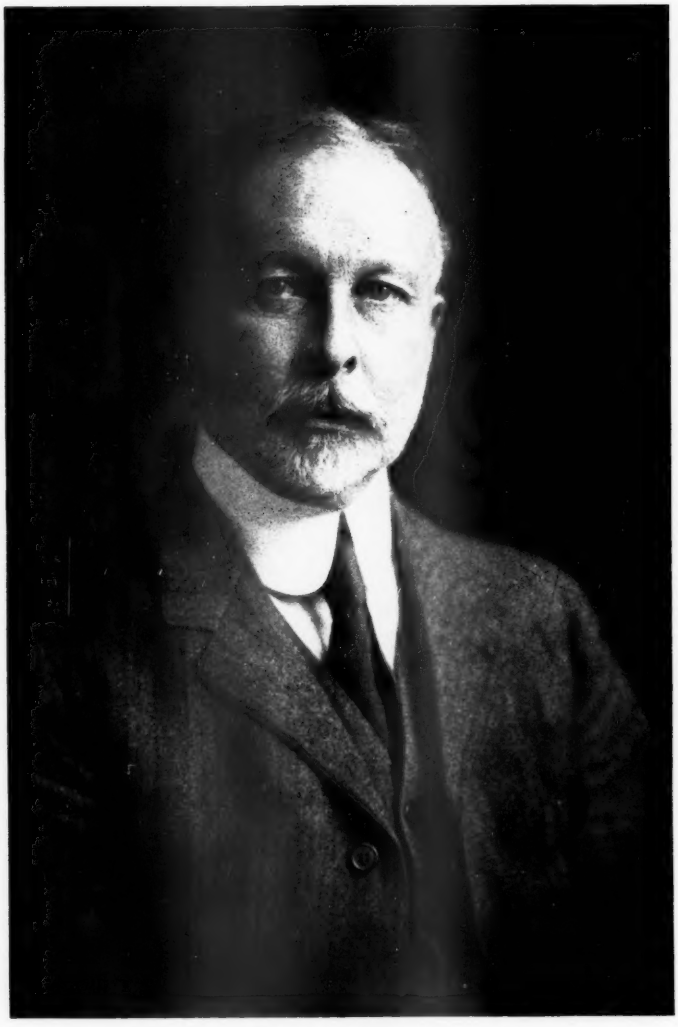
If we should seek to criticise the arrangement there would be no end, and the reader would find himself regarding the volumes with the idea that he could improve upon them in this line; but after going through the books very carefully we have decided that the editors have had their own troubles, and that this feature is about as clear as it is possible to be made. And although the reader may be misled in some of the groupings, the index is the most thorough and accurate of any book we have considered, as any subject may be found under two or three different heads.

Each subject is treated with a conciseness and clearness that are very commendable, and the reader who follows his text closely will find all of the necessary details present.

The illustrations are profuse where necessary, and serve to make the book interesting to those who enjoy illustrations. The articles on the operative treatment of fractures by W. Arbuthnot Lane and on orthopedic surgery by Robert Jones are especially well illustrated.

The print is good, the paper thin and agreeable to handle. On the whole, we feel that these volumes will be of great value to many physicians.

WM. R. CUBBINS.



E. Wyllys Andrews

Chairman, Committee on Arrangements for Chicago Session, November, 1913